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FORENSIC MEDICINE

AND

TOXICOLOGY

A MANUAL FOR STUDENTS

BY

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PREFACE TO THE SECOND EDITION.

THE recognised facts and principles of Forensic Medicine, as defined by acknowledged authorities, are here classified and arranged with the object of assisting students engaged in preparing for examination. The present Edition has been revised, and a few illustrations introduced. The figures on pages 68 and 88 are taken from Dr. Luff's *Text-Book of Forensic Medicine and Toxicology*, by permission of Messrs. Longmans & Co.; for that on page 123 I am indebted to Messrs. Gurney & Jackson, the publishers of Prof. Attfield's *Chemistry: General, Medical, and Pharmaceutical*, from which book the figure is copied.

C. O. H.

December, 1896.

FORENSIC MEDICINE AND TOXICOLOGY.

Forensic Medicine teaches the application of the various branches of medical knowledge to the purposes of the law. By its study a medical man is made competent to act as an *expert or skilled witness* in various legal proceedings; that is to say, he is able to offer to the legal authorities reasoned inferences and opinions concerning the ascertained facts in various cases which become the subject of legal investigation.

Causes of Sudden Death.—Cases of sudden death frequently give rise to legal proceedings. Sudden death may result from natural causes, or from accidental or criminal violence.

The *natural* causes of sudden death may be generally traced to some injury to, or impediment to the action of, the heart, lungs, or brain. These organs have been spoken of as the *tripod of life*. When failure of the heart is the primary cause of death, the person is said to die by SYNCOPE. Hæmorrhage, shock, aortic disease, etc., may cause death by syncope. Syncope may result from *anæmia* or *asthenia*. The first may be due to sudden and considerable loss of blood, the cardiac muscle still remaining strong. Asthenia—want of power—may be induced by wasting

diseases, starvation, etc. When the function of respiration is primarily interfered with, as in drowning, hanging, etc., or by injury to the upper part of the spinal cord, death is said to occur by ASPHYXIA (sometimes called *apnœa*). If the brain is the organ primarily involved, as in apoplexy and some forms of poisoning, the person falls into a state of complete insensibility, and is said to die by COMA.

The *violent* causes of death, whether sudden or protracted, which chiefly require the skill of a medical jurist for their elucidation, are poisoning, wounds, and personal injuries, such as burns and scalds, and such causes of death as hanging, drowning, strangulation, etc.

Positive Signs of Life.—The ordinary evidences of life (voluntary movement, cardiac action, respiration, etc.) may be indistinct, or, to uninformed persons, apparently absent, in cases of syncope, catalepsy, asphyxia, etc. Some of the following signs must be sought for, to establish the fact that life is still present:—

1. CARDIAC ACTION.—Even if there is no arterial pulse or cardiac impulse the heart's sounds may perhaps be heard. This is more particularly true of the second sound when the stethoscope is placed over the aortic cartilage. Auscultation on either side of the manubrium sterni may detect the respiratory murmur in the large bronchi. Complete cessation of cardiac action for a few seconds (six or seven) is with great probability incompatible with life—an interval of a few minutes (say five) may be regarded as certain proof of death. The action of the heart never continues more than four or five minutes after respiration has ceased.

2. MUSCULAR MOVEMENTS.—Respiratory action, how-

ever feeble; reflex contraction of the pupil; conjunctival reflex. The movements of down placed upon the lips to test the existence of a respiratory current are not reliable.

3. VESICATION.—The production of redness or of a blister on the application, say, of a heated spoon or strong ammonia, proves the power of vital reaction in the blood-vessels and tissues.

4. POPULAR TESTS are :—Holding a mirror in front of the mouth and nostrils to see if it is made dim by the breath; placing a lighted candle behind the hand to determine whether a translucent red appearance can be detected in the web of the fingers; tying a ligature round a finger and observing whether the distal parts become congested and swollen; introduction of a needle into some fleshy part of the body—if life is present the steel, after a time, becomes oxidised.

Positive Signs of Death.—The absence of the signs above described would show that death has occurred. But certain positive evidences may also be noted. These are :—

1. CHANGE OF COLOUR.—The skin becomes white and pallid in consequence of cessation of the circulation. This change may be more or less concealed in very florid persons, in those of dark complexion, and in cases of jaundice and other pigmentations of the skin. In poisoning by carbonic oxide the blood remains of a rosy tint, and the skin, more or less distinctly, shares in this. In some cases patches of livid discoloration (cadaveric hypostases) appear on the surface. Loss of elasticity in the skin is also a marked feature shortly after death.

2. CHANGE OF TEMPERATURE.—A dead body *gradually* cools down to the temperature of the surrounding medium.

The loss of heat is earliest manifested in the limbs, as the amount of surface exposed, relative to the bulk, is much greater than in the trunk. Hence there are greater opportunities for removal of heat by radiation and conduction and convection. These influences, and the cessation of the vital activities of the tissues, account for the cooling of the body after death. The rapidity of the cooling will obviously be influenced by such conditions as whether the body is clothed or not, whether it is fat or lean, etc. A body will cool more rapidly in water than in air. The bodies of newly-born children cool rapidly. Cooling of the body is also rapid when death is due to a considerable hæmorrhage. After death from any acute disease, a high temperature may be retained for some hours, and in the bodies of persons who have died from cholera, yellow fever, small-pox, acute abdominal diseases, some forms of apoplexy, etc., the temperature has been observed to rise for a time after death. *Gradual and progressive cooling is a sign of death, whilst, if the body is quite cold, it may be concluded that it has been dead at least from eight to twelve hours.*

3. Changes in the Eyeball.—Shortly after death the brightness of the cornea disappears, and it soon becomes opaque, wrinkled, and flattened. The entire eyeball also becomes flaccid and sinks in the socket. The pupil is insensitive to light, and the front of the eyeball to touch. The pupils dilate at the time of death.

4. Flaccidity of Tissues (Primary).—After death the muscles become flaccid. There is loss of muscular tone; hence the jaw drops, and the limbs are lax and flabby. The muscles, however, retain their irritability and therefore respond to stimuli (*e.g.*, electricity).

5. RIGOR MORTIS or CADAVERIC RIGIDITY (see below).

6. PUTREFACTION or SECONDARY FLACCIDITY with loss of muscular irritability (see p. 13).

Note.—By attention to the points under 2, 4, 5, and 6, an approximate estimate may be made of the time that has elapsed since death occurred.

Rigor Mortis.—In this condition the muscles become rigid, inelastic, and acid in reaction.

Rigor mortis is a change in the muscles themselves, and is independent of the nervous system. Muscles which are much shattered, as in cases where death occurs with comminuted fractures, do not become rigid. The rigidity is due to coagulation of the myosin; this is said to result from the action of the lactic and carbonic acids developed in the muscle after death. It is not a result of the cooling of the body, for, if this were the case, the limbs, which are the first parts to cool, would be the first to stiffen, whereas, as a matter of fact, the muscles of the limbs are the last to become rigid.

Rigor mortis appears earliest in the muscles of the neck and lower jaw, and subsequently extends to the trunk and upper limbs, and, lastly, to the lower limbs. It passes off in the same order. With the development of rigor mortis there is slight shortening of the muscles, so that the limbs, if not otherwise prevented, stiffen in the position of slight flexion. The involuntary muscle is affected rather earlier than the voluntary variety. The heart, indeed, frequently becomes rigid within an hour or so after death and remains in this condition for twelve to thirty-six hours.

The length of time which elapses between death and the appearance of rigor mortis varies much—as an average,

five to six hours may be given. The rigidity soon appears when the patient has died from some wasting disease, or under other conditions (*e.g.*, repeated convulsions) which greatly reduce the irritability of the muscles. Its appearance, on the other hand, is delayed when death comes suddenly upon a person in full vigour. In some cases of poisoning by charcoal fumes it has been observed that rigor mortis has been late in its appearance and prolonged in its duration.

Rigor mortis may continue from a few hours to several days; the average duration is from sixteen to twenty-four hours. When its appearance is delayed, it persists for some time; whilst when it soon appears, it lasts but a short time. A body sunk in cold water soon becomes rigid, and the rigidity persists for a long time. Cold and dry air favour the prolongation of the period of rigidity. It is of longer duration in winter than in summer, other things being equal.

Rigor mortis is distinguished from *spasm*, the result of disease, by bending the limbs. In spasm the limb returns to its original position as soon as the bending force is removed, whilst in rigor mortis the rigidity, when once overcome by force, does not return. The fact that the body is warm, and other evidences of life, would also indicate the impossibility of the rigidity being due to rigor mortis.

A *frozen body* is distinguished by the fact that all the muscles are equally stiff; the crackling of the ice in the tissues can be heard when a limb is bent; and particles of ice may be seen on cutting into the tissues.

Cadaveric Spasm.—This is seen in cases where some violent muscular action is taking place at the moment of

death. The contraction continues after death and may pass right on into cadaveric rigidity without the intervention of any period of primary flaccidity. A weapon may thus be found firmly grasped in the hand of a suicide, and the discovery of a weapon so held is one of the best possible proofs of suicide. This close grasp cannot be simulated by placing a weapon in the hand of a dead man so as to give the appearance of grasping. Hence a weapon only loosely held in the hand may have been placed there after death by some one desirous of suggesting that death has been by suicide. But a weapon loosely held does not necessarily destroy the theory of suicide, because muscular relaxation may quite well follow the firm grip present at the moment of the infliction of the wound. And often, indeed, the weapon with which a suicide has taken his life is found to have fallen entirely out of his hand.

Putrefaction.—After rigor mortis has passed off the tissues again become flaccid (*secondary flaccidity*), but there is now no response of the muscles to stimuli. This secondary flaccidity with loss of muscular irritability is an absolute proof of death. It is due to putrefaction. Putrefaction is a chemical process in which the complex organic compounds of the body break up, under the influence of certain micro-organisms, into simpler combinations (*e.g.*, H_2O, CO_2, NH_3). It is evidenced by three signs, viz.:—

1. Change in colour of the tissues.
2. Softening of the tissues.
3. The development of a characteristic odour.

Bruises are distinguished by the absence of odour.

Gangrene produces softening and some odour, but the odour is different from that of putrefaction. In gangrene also there is a distinct line of demarcation, whilst the change of colour due to putrefaction gradually shades off into the normal skin. Again, gangrene is almost invariably confined to the extremities, whilst the earliest and most marked evidences of putrefaction are found on the trunk.

The rapidity with which putrefaction occurs varies with a variety of circumstances. A fat and flabby, or a much mutilated body, decomposes rapidly; so also does a body, death of which has occurred after acute inflammatory (especially abdominal) disease. The bodies of infants soon show evidences of putrefaction, whilst those of spare and old people putrefy slowly. In cases of chronic exhausting diseases (unless accompanied by dropsy), and after death from hæmorrhage, decomposition is slow. Bruises and wounds soon display signs of putrefaction and so may appear after death to be more extensive and severe than was actually the case

Certain poisons have been credited with influencing the rate of putrefaction. Morphine and hydrocyanic acid have been said to hasten it, strychnine to delay it. The fact seems to be that the same poison may in different cases act in directly opposite directions, according to the mode in which it operates on the muscular system before death. Thus, when strychnine rapidly destroys life without exhausting the irritability of the muscles, rigor mortis is late to appear and is prolonged, and putrefaction proceeds slowly. But when death has been preceded by repeated convulsive seizures, and muscular irritability has thus been much reduced, rigor mortis soon appears and is of short duration, and putrefaction takes place early and proceeds rapidly (Taylor).

Arsenic has a well known preservative influence on animal matter. Hence the bodies of persons poisoned with arsenic remain long in a good state of preservation. To this rule, however, there are exceptions. The popular belief that by burying a body in lime putrefaction is accelerated is not correct. Indeed, the lime, by removing moisture from the body, delays putrefaction.

The external conditions which influence putrefaction are air, moisture, and temperature.

Free access of air hastens putrefactive changes; absence of air suspends them. Air, of course, supplies the oxygen needed for putrefactive changes, and it also conveys the micro-organisms on which, at least to some extent, such changes depend. Moisture favours putrefaction; hence dropsical bodies, and bodies removed from water, decompose rapidly. When a body is immersed in water, air, of course, is to a large extent excluded, and putrefaction is slow. Temperature also has a very important influence. From 70° to 100° F. putrefaction is rapid; at 32° it is arrested, but on subsequently raising the temperature it proceeds with great rapidity. A temperature from 120° to 212° drives off the fluid from the body and arrests putrefaction; in this way the body may be dried or mummified.

In summer, putrefaction is at least three times more rapid than in winter. The changes which occupy in air one week, occupy in water two, and in earth eight weeks, the temperature in the three cases being the same. The rapidity of decomposition in a buried body will vary with the nature of the coffin, the character of the soil, and the amount of moisture in the soil. The most persistent parts are the bones, teeth, and hair.

The earliest manifestation of putrefaction is a greenish coloration of the anterior abdominal wall. This appears in from one to three days after death—the latter date more commonly. In about a week's time other patches have appeared and united, and the abdomen is distended with gas, and the eyeball collapsed. The order of the parts on which the colour changes appear is abdomen, chest, face and neck, lower limbs, and lastly the upper limbs. In from fourteen to twenty days the epidermis is raised in *bullæ*, the nails can be pulled out, and the face and body are swollen from the accumulation of gas in the cellular tissue. The first of the internal organs to show evidences of putrefaction are the larynx and trachea, as these are open to the air; the mucous lining shows a brownish-red or sometimes a greenish colour. In young children the brain very early begins to decompose; its tissue is very soft and contains a large proportion of water. The stomach, intestine, spleen, and liver, are all organs which display putrefactive changes at an early date—sometimes as early as three days after death, sometimes not for a week or more. Later in undergoing putrefaction are the heart and lungs, kidneys and bladder, œsophagus and diaphragm, blood-vessels (aorta) and uterus. The last two are sometimes very persistent and have been recognised as late as twelve months after death.

The following gases may be evolved during the progress of putrefaction:—

H_2S—Known by odour; it blackens paper dipped in solution of lead acetate.

NH_3—Smell; turns red litmus blue; gives white fumes with HCl on glass rod (ammonium chloride).

These are the gases given off during the earlier stages; later are found:—

CO_2—Extinguishes a light; white precipitate with lime water.

CH_4—Inflammable; burns with a yellowish flame.

PH_3—Yellow stain on paper moistened with solution of silver nitrate.

Nitrogen is also produced during putrefaction.

The pressure of gas accumulated in the body sometimes causes the discharge of alimentary and fæcal matter from the outlets. The same influence accounts for the escape of blood, some days after death, from wounds involving any of the larger veins.

Adipocere.—The soft tissues may, at a variable period after death, be more or less completely converted into *adipocere.* This is a soap formed by the action of ammonia (one of the products of decomposition) upon the fat of the body. Oleate and stearate of ammonium are thus formed. It is a white or yellowish white substance of low specific gravity, and having an odour something like decayed cheese. The fat, as in the breasts, buttocks, renal regions, etc., is the first to undergo this change. The muscles and viscera may later be changed into adipocere. When once formed it remains long—probably permanently—without change. If the grave is traversed by springs of water containing salts of calcium, the ammonium of the adipocere may be replaced by calcium. In these circumstances adipocere is whiter and firmer than when, as is usually the case, it is an ammoniacal compound.

Adipocere is rarely formed before two months, and generally not earlier than four or five months, after death.

Identification.—Medico-legal questions of identity may occur both in connection with living persons and with dead bodies or portions of dead bodies. Assistance in the identification of the living may be obtained from congenital deformities (*e.g.*, hare-lip), congenital marks (*e.g.*, nævi, moles, etc.), the colour of the hair, and from acquired marks such as cicatrices and tattoo-marks.

Cicatrices.—Any wound which involves the true skin will leave a cicatrix. Slight punctures or incisions with a lancet, or leech-bites, affecting only the surface of the cutis, may leave no trace after a few months. Even a clean cut, if healing has occurred under favourable circumstances, may produce a linear cicatrix which it is difficult to detect. But any injury causing loss of substance of the true skin, and healing by granulation, will necessarily involve the production of a cicatrix. This cicatrix, moreover, is permanent—it does not disappear. At first pinkish in colour and soft, it soon becomes harder, whiter, and less sensitive than the surrounding skin; at the same time it gets smaller, and may therefore give an erroneous impression of the size of the weapon by which the wound was produced. This shrinking is especially marked in a cicatrix the result of a stab. A cicatrix does not give much information regarding the time of the infliction of the injury from which it results. If recent, it can be recognised as such, but when it has acquired a characteristic hard, white, shining appearance, which it does in about six weeks, one cannot say anything as to its age except that it is not recent. A scar which is not very distinct may be made prominent by rubbing the part. The resulting redness of the surrounding skin makes

conspicuous by contrast the whiter (less vascular) cicatrix. The special characters of cicatrices resulting from syphilitic or strumous ulceration, from small-pox, and from surgical operations, make these scars specially valuable as aids to identification. Vaccination marks, and the scars produced by wet-cupping also have characters of their own—these marks, however, do sometimes disappear. The evidence derived from cicatrices must be associated with the consideration that it is just possible that two different persons may have cicatrices identical, or practically identical, in their characters. It should be remembered, too, that a cicatrix in a child may increase in extent with the growth of the child.

Nævi and Moles.—These may give valuable aid in questions of identification. In the first place they cannot be artificially produced. In the second place they do not disappear and can only be removed by an incision or by some caustic application, either of which will lead to the production of a cicatrix.

Tattoo-Marks.—These, as a rule, are permanent, or at least can only be removed by the application of some strong acid, which will produce a scar. The scar may be pigmented. If the tattooing operation has been a very superficial one, the mark may disappear in the course of time. In some of these cases the colouring matter has been found in the neighbouring lymphatic glands. The red colours are most disposed to fade, whilst the black, especially that of China-ink, are among the most persistent (Taylor).

Colour of the Hair.—The hair may be dyed for the

purpose of concealing identity. It may be dyed black by various methods. The hair may be smeared with a paste made of litharge, lime, and chalk, and a hot head-dress worn for some hours. It may be washed with a solution of ammonio-nitrate of silver, and subsequently with a solution of pyrogallic acid. Bismuth is also used to darken the hair. To detect these agents the hair should be burnt, the ashes treated with nitric acid, excess of acid neutralised, and chemical tests applied to the solution.

Dark hair may be made fair (auburn to white) by washing with chlorine water, or oxygenated water.

Saffron water produces various shades of red.

Hair can be made coarse by solution of permanganate of potassium.

The fact that the hair has been dyed can be detected by keeping the individual under observation for a time, access to any dyes being prevented.

Foot-prints.—These may be of the naked sole or of a boot. The evidence they yield is hardly a matter for a medical witness. A cast of an imprint made in soil may be taken in paraffin. Heat the print by means of a hot iron held over it, then sprinkle in a layer of powdered paraffin; repeat the process until the foot-print is filled up. A cast of a foot-print in snow may be taken by pouring into it a solution of gelatine just about to solidify. In the case of a foot-mark produced on stone or wood by a foot stained with blood, the suspected person's foot should be dipped in some coloured fluid and an impression taken. This can then be compared point by point with the original stain.

Photographs and Anthropometry are now largely used for the identification of criminals. The latter involves the scientific measurement of the head and various parts of the body.

Identification of a Dead Body.—If found soon after death there is as a rule no difficulty. Relatives or acquaintances may be able to recognise and identify the body by the features, bodily peculiarities, clothing, etc. It is where decomposition is advanced, or the body is much mutilated, or only part of the body is found, that the services of a medical jurist are specially required. The following rules should be attended to:—Any clothing should be retained, ornaments especially are often valuable aids to identity; a cast should be taken of the features, a portion of the hair retained, the state of the dentition carefully examined, and, if there are artificial teeth, the whole jaw should be kept to be compared with the dentist's cast; the height of the body (allow 1 to 2 inches if only the skeleton is found), whether fat or lean, the length of the neck, the character of the hands, the presence of any congenital or acquired marks, should all be carefully noted. It is to be remembered that all notes are to be made on the spot; only notes so made can be used in court to refresh the memory of the witness.

The Determination of Sex.—When mutilated remains are found the genitalia may be absent. The following considerations will help to determine the sex:—

The male has more hair over the body generally.

The pubic hair in the male runs up in the middle line

towards the umbilicus; in the female the upper limit forms a transverse line across the abdomen.

The male umbilicus is nearer the xiphoid than the pubes; in the female the reverse is the case.

The thyroid cartilage is more prominent in the *adult* male. If the head alone is found, only a probability can be established from the size of the head, weight of brain, length of hair, existence of beard, etc.

The Determination of Sex in Skeletons.—This can only be accomplished with confidence when the skeleton is that of a person who has passed the age of puberty. Note the following:—In the female the bones generally are more slender, less curved, and less distinctly marked by muscles, and the cartilages (*e.g.*, costal and xiphoid) show less tendency to ossify.

In the female the angle formed by the neck of the femur with the shaft approaches a right angle; in the male the direction of the neck is more oblique, so that it forms a large obtuse angle with the shaft of the bone. In the female, too, the internal condyle of the femur is more prominent than in the male.

The pelvis, however, offers the most satisfactory evidence. In the female, the ilia are more expanded; the inlet of the true pelvis is more nearly circular, the sacral promontory projecting less into it; the sacrum is flatter and broader; the coccyx more movable; the depth of the symphysis pubis is less; the sub-pubic angle is larger; and the width between the ischial tuberosities is greater. In the male the obturator foramen is nearly oval in shape; in the female it is rather triangular, or narrowed at its lower part. In

advanced life the skeleton of the female loses some of its more distinctive sexual characters.

The Determination of Age in Skeletons.—To accomplish this, attention must be specially directed to the state of ossification of the skeleton, to the size of the angle of the lower jaw, and to the state of the dentition.

Under puberty, the size of the bones, the extent to which union of the epiphyses with the shafts has progressed, and the state of the dentition, will guide the judgment. In infancy, the angle of the lower jaw is obtuse.

In *the skeleton of an adult* (say over 25 years of age), all the epiphyses will be joined to the shafts, and the bones will be strong, with distinct muscular markings. The angle of the lower jaw will be nearly a right angle. The eruption of the wisdom teeth may be expected. The sutures of the skull will be closed or obliterated. The age, however, when adult age has been attained, can only be indicated within comparatively wide limits.

The bones of an old person are more brittle, lighter, and have larger medullary cavities. There is evidence of ossification in the cartilaginous skeleton. The bones of the skull are thinned. The teeth are lost. The angle of the lower jaw is obtuse, and the body of the bone narrowed by absorption of the alveolar border.

When a complete skeleton is found there can be no difficulty in deciding whether it is or is not a human skeleton. The same is true of any one complete bone. But a portion only of the shaft of a long bone would need to be spoken about with caution.

Bone, as such, is recognised by the presence of lacunæ

and Haversian canals. It is known that the lacunæ are largest in reptiles, smallest in birds and mammals, whilst in fishes they are intermediate in size.

The Recognition of the Cause of Death.—As cases of sudden death are frequently the subject of legal investigation, the medical jurist may be called upon to determine in particular instances the cause of death. He must therefore be familiar with the *post-mortem* appearances in the various forms of violent death. He must also be prepared in many cases to express an opinion, and to support his opinion by reasons, as to the possibility or probability of the death being a suicidal, homicidal, or accidental one. Further, as sudden death may occur from various natural causes, he must be prepared to distinguish between the *post-mortem* appearances in such cases and in cases resulting from accidental or criminal violence. A *post-mortem* examination in connection with any medico-legal enquiry must only be made when authority to do so has been given. In England the authority is provided by an order from the coroner, whose duty it is to investigate all cases of death occurring suddenly or under suspicious circumstances. The order may be issued to any medical practitioner, and he must obey it, and attend, when summoned, to give evidence in the Coroner's Court. In Scotland, a warrant is issued at the instance of the Procurator-Fiscal, and the examination is usually made by medical inspectors officially appointed for the purpose, who draw up and sign an authoritative report. If the case goes to trial they will be called as witnesses, and may be examined and cross-examined upon the report they have submitted. Some of the causes of

violent death, and certain medico-legal questions arising out of them, will now be considered.

Starvation.—This is not a common cause of death. Some diseases (*e.g.*, cancer of the œsophagus) may produce it. In the case of children and infirm or aged adults, there may be criminal neglect to supply food suitable in quantity or quality, or wilful withholding of food by the guardians or attendants. These may therefore be charged with homicide. As a means of suicide, starvation is very uncommon; it may, however, be adopted by lunatics. Famine, shipwreck, etc., may cause accidental starvation.

Symptoms.—Pain in the stomach, relieved on pressure; hunger, soon succeeded by intense thirst; progressive loss of weight; coldness of the surface; eyes glistening, with dilated pupils; skin exhales an offensive smell, and sometimes becomes covered with a brownish varnish; convulsions and delirium may precede death. The last symptom has been described as occurring in shipwrecked mariners and may perhaps be due to exposure to the sun or to the drinking of salt water.

A healthy adult completely deprived of food will probably survive from seven to ten days. A very small quantity of fluid, taken occasionally, will considerably prolong life. Some few years ago an Italian in this country abstained from food for 40 days; he took as much water as he desired and occasional doses of some narcotic; no manifest ill results followed. Women die from starvation earlier than men; fat people earlier than lean; and children earlier than the middle-aged and elderly. Exposure to cold and hardship will hasten death.

Post-mortem Appearances.—It is in cases in which the supply of food has for some time been insufficient, rather than those in which it has been altogether withheld, that anything like decided positive *post-mortem* evidence is obtained. The body is emaciated and unduly light; the subcutaneous tissue and organs generally are free from fat; the gall-bladder is distended; the walls of the intestines are much thinned and may be extremely translucent. These are the only signs which are diagnostic. Other appearances noted are:—A dry and shrivelled condition of the skin; eyes open, and with a fiery red appearance; alimentary canal empty and contracted; blood scanty and dark. The presence of milk, starch, or other food in the stomach would be presumptive evidence against death from starvation. Even if a positive affirmative opinion cannot be given, the absence from the body of all signs of fatal disease, and such appearances as above described, would justify the statement that the results of the *post-mortem* examination were consistent with the theory of death from starvation.

Death from Cold.—Mere exposure to cold is not a common cause of death in this country. In most cases of death from exposure the want of proper food has been a contributing condition. Fatigue and intemperance weaken the resistance which the body can offer to the influence of cold, and infants and young children readily succumb to exposure and cold.

The *local effects* of cold are diminution and even suspension of the circulation, more especially in the extremities, ears, nose, etc. These parts become shrunken, livid, and numb. Even gangrene may occur.

The *constitutional effects* are congestion of the viscera of the chest and abdomen, and of the brain—hence the tendency to sleep, stupor, and sometimes convulsions. Sometimes the central nervous system seems to be directly attacked, and general tetanic spasms are produced.

Post-mortem Appearances.—There are none absolutely characteristic. In forming an opinion as to whether death was or was not due to cold, the circumstances under which the body was found, and the absence of all *post-mortem* signs of disease or violence, must be considered. The following signs may be expected:—Surface pale; cutis anserina marked; countenance calm; congestion of vessels and sinuses of brain, sometimes serous effusion; thoracic and abdominal viscera congested; rigor mortis, as a rule, late to appear; and putrefaction delayed. Thus, a body found in the snow with vascular surface, internal organs not congested, and putrefaction advancing, must have been placed there after death.

Death has occurred from suddenly drinking a large quantity of cold water. The symptoms have simulated those of poisoning by hydrocyanic acid.

Sun-Stroke, Heat Apoplexy, or Insolatio.—The symptoms due to exposure to excessive heat range from slight attacks of nausea and giddiness, with headache, to complete unconsciousness, with a hot, dry skin, and considerable elevation of temperature (hyperpyrexia).

Sudden death may be due to cerebral congestion (coma); or to failure of the heart (syncope); or, after a few days, pulmonary complications may arise, or serous effusion into the brain may occur. Those who recover

are liable to develop epilepsy, insanity, or other nervous disorders.

The *symptoms and post-mortem appearances* vary with the mode of dying. As a rule, the brain is much congested, with serous effusion into the ventricles, and the blood is fluid and dark with general venous congestion. Rigor mortis and putrefactive changes usually appear soon.

Death from Lightning.—Lightning may produce a mere momentary stunned condition followed or not by various nervous troubles. It may cause instantaneous death from "return shock" without any apparent injury, or such a degree of mutilation that an appearance of criminal violence is produced. As a rule, unless death is immediate, the individual completely recovers.

Post-mortem Appearances.—These will necessarily vary much in different cases. There may be neither external nor internal injury; or no external signs, but the internal organs much injured and even reduced to a pulp; or again, much mutilation of the soft parts and sometimes fractures of bones. Other appearances observed are:—Clothes singed, burnt, or torn, shreds sometimes carried to a distance; boots torn, especially if they have metal or nails on sole; coins, watch-case, etc., fused; skin bruised, sometimes with an arborescent appearance, blistered, burnt; hair singed; an appearance like a bullet-wound has been observed. Rigor mortis may come on promptly or after an interval, and putrefaction, as a rule, commences early.

Death from Burns.—Accidental deaths from this cause are not uncommon among women and children. Homicide

by burning is rare, but a murderer may attempt to dispose of the body of his victim by burning, or may use the same means with a view to conceal wounds, etc., and to suggest that death has been due to accident. Only very rarely is burning selected as a means of suicide. *Spontaneous Combustion* of the body is now known to be quite impossible—if a body is found with burns on it, these have certainly been produced by fire applied from without. Some authorities have held that in certain cases, as *e.g.*, in those addicted to alcohol, the tissues are unusually combustible. This is extremely improbable. The large amount of moisture (about 72 per cent.) which the tissues contain renders them highly incombustible. Still there are a few cases on record which seem to lend some force to the suggestion.

The *local effects* of burns and scalds vary with the following circumstances:—

1. Part protected (*e.g.*, by clothes) or not.
2. Delicacy of the skin.
3. Temperature of heated substance, and duration of application; hence six degrees of burns are described, viz.:—

(*a*) Simple inflammatory redness, often followed by desquamation.

(*b*) Vesication, the cuticle being raised into vesicles containing yellow coloured serum; generally produced by boiling liquids. As the cutis is not destroyed, no cicatrix is produced.

(*c*) Superficial parts of cutis destroyed, and a thin yellow eschar produced. A cicatrix which shows but little tendency to contract follows.

(*d*) Cutis destroyed down to cellular tissue, and a firm and thick eschar produced.

(*e*) Skin, subcutaneous tissue, and a portion of the muscles are converted into a thick eschar. The cicatrix of (*d*) and still more of (*e*) shows a decided tendency to shrink.

(*f*) Carbonisation—the whole thickness of the part is reduced to charcoal.

4. Nature of heated substance:—Boiling water causes vesication and a sodden state of the skin and flesh; molten metal, parts destroyed or charred; heated solid, gives a blackened, shrivelled appearance to cuticle; flame produces extensive scorching; explosion of gunpowder causes scorching with deposit in the skin of particles of unburnt carbon.

Burns as a cause of Death.—Exposure to fire may, in different ways, produce constitutional effects which may be the immediate cause of death. Death may be due to:—

1. Asphyxia—from absence of pure air, and the respiration of gases resulting from combustion. CO_2 darkens the blood; CO renders it lighter (Taylor).

2. Coma—sometimes, and more especially in children, a condition of stupor is produced, and this may pass into coma and death. Hence, opium should be avoided in treatment, or the death of the patient may involve the medical man in a charge of malpractice.

3. Shock—due to the sudden and violent impression made on the nervous system. This is frequently the case in children. Death from shock may occur immediately or may be postponed for several days.

4. Congestions and inflammations of the viscera and brain; serous effusions into ventricles, pleura, etc.; duodenal ulcer with perforation. These occur during the period of reaction, say from the second to fourteenth day.

5. Exhaustion from prolonged suppuration or gangrene. It is in burns of the fourth, fifth, and sixth degrees that this is most likely to occur.

6. Tetanus may follow burns.

7. Cicatrization may cause deformity in burns of the

fourth and fifth degrees, especially if involving the flexures of a joint or situated near one of the orifices.

Post-mortem appearances.—The surface will give local evidences as redness, vesication, eschar, or charring. The internal signs will vary with the mode of dying. In death from shock nothing abnormal may be detected. Asphyxia will show the lungs, right heart, venous system, and viscera engorged with dark blood; the left heart contracted, and the arteries with little or no blood. In cases in which the blood is bright red, suffocation has probably been due to carbonic oxide, though such a colour of the blood is sometimes found with the ordinary oxy-hæmoglobin spectrum (see p. 87). When the patient has died during the period of reaction, signs of inflammation in some of the viscera may be expected; serous effusions, especially in the brain, are common.

Has the person died from the effects of the burning?—In answering this question consider:—

1. The severity of the burn. A burn extending over a large surface, though not penetrating deeply, is much more dangerous to life than a limited deep burn. Burns involving a half or a third of the surface are almost certainly fatal. Presumably the injury to so large a sensory surface, and the destruction of the excretory and heat regulating influence over such an extensive area, are responsible for this.

2. Age and strength of person. Both very young and very old persons easily succumb to the influence of burns.

3. Internal *post-mortem* appearances.

4. Absence of any other apparent cause of death.

Were the burns produced before or after death?—To answer this question note:—

1. A Line of Redness.—In a burn produced during life

the skin immediately surrounding the burnt part shows a dead-white line; outside this is a *deep red line* which shades off into a diffused redness. This diffused redness is removable on pressure, and generally soon disappears after death. The deep red line, however, persists after death and is not removed by pressure. The presence of this line therefore is a proof that the burn was inflicted before death. The absence of this line, however, is no proof that the burn was inflicted after death, as it is only in burns of a certain degree of severity that it is produced, and even in severe burns it is not always present.

2. VESICATION.—A vesicle containing thick, coagulable serum, and having a well-marked permanent red ring round it, is strongly diagnostic of a vital burn. Vesicles containing air, or even watery serum, may be produced by the application of a hot iron to the surface of the body shortly after death. In dropsical subjects blisters may be produced even many hours after death. But such blisters contain either air, or thin watery serum, which may be blood-tinged. The serum only gives a slight reaction with heat or nitric acid, whilst the serum in an *ante-mortem* vesicle is rich in albumen and gives an abundant response to these tests. There is of course no permanent red ring round these *post-mortem* vesicles.

3. SUPPURATION, or evidences of separation of a slough would be absolute proof that a burn had been inflicted before, and necessarily some time before, death. The time a person has survived a burn can only be estimated by noting the extent to which these processes have progressed; and by comparing the state of several burns found in a body from this point of view, a judgment may be formed

as to whether they were or were not produced at the same time.

4. The detection of carbonic oxide in the blood (see p. 47), and the presence of particles of soot, etc., in the respiratory passages, would support the suggestion of vital burning, because such facts indicate that respiration was attempted during exposure to the fire. (Luff.)

Whether a burn is the result of accident or intention must be determined by other than medical evidence. *Post-mortem* burns are of course usually inflicted intentionally.

Drowning.—A person is drowned when air is prevented entering the respiratory passages by the immersion of the entrances to these passages—the mouth and nostrils—in a fluid or semifluid medium. Under such circumstances, air escapes from the lungs and water enters, but no air can gain admission to the lungs. The blood which is circulated through the body is therefore venous in character. The tissues are thus poisoned. After a short period of violent respiratory effort the respiratory centre is exhausted, and pulmonary respiration ceases. The heart beats more and more feebly, and ultimately stops, and death ensues. *Complete* submersion for a few minutes, five at the outside, is sufficient to produce this result. In some cases death is not, or not purely, by asphyxia. Thus, the fear of death, or the severe shock from sudden immersion, especially after falling from a height, may produce syncope. Or the person may be more or less comatose before he reaches the water, as from intoxication, or from his head striking some object during his fall. In such cases there may be little or no effort at respiration, and the *post-mortem* appearances will

not be those of asphyxia but of syncope, or coma, or of a mixed character.

When a body is found in the water the question arises whether death has been due to drowning, or whether the body has been placed in the water after death. In the absence of direct evidence this question may fall to be determined by *post-mortem* examination.

EXTERNAL *POST-MORTEM* APPEARANCES—

Cutis anserina.—This is usually seen, and most conspicuously seen, on the front of the extremities. It is due to the contraction of the bundles of muscular fibres in the integument, and is therefore a vital phenomenon. It is not always present, and does occur in other violent deaths, *e.g.*, hanging. It is probably a result of nervous shock.

Countenance is a little swollen, placid, and pale; eyes half open, with dilated pupils; watery froth over nostrils and mouth; tongue sometimes pushed forward and even lacerated by the teeth.

Skin of palms and soles is livid, grey, and wrinkled. This is due simply to soaking in the water. It only proves that the body has been in the water from twelve to twenty-four hours or more.

Retraction of penis.—A vital act due to muscular contraction under the influence of fright and cold. It is by no means always present.

Abrasions and excoriations on the hands.—These in themselves are of little importance, as they might have been produced during life in various ways, and possibly may be caused in dragging the body from the water. But, if with these there are signs of muscular activity after entering the water, such as sand, mud, weeds, etc. (similar to those found

in the river or pond), grasped in the hand or lodged under the nails, such evidence would be of great value as proof of death by drowning.

Rigor mortis comes on early and persists for a long time.

INTERNAL *POST-MORTEM* APPEARANCES—

The body of a recently drowned subject will present the appearances indicative of asphyxia. The venous system will be found engorged with dark-coloured liquid blood. The brain will share more or less in the general venous congestion, but extravasation of blood into the brain is very uncommon. It is in the respiratory and circulatory organs that the characteristic signs must be expected.

Trachea, etc.—The epiglottis is found erect. The mucous membrane of the larynx and trachea is injected and dusky red; over it is found a more or less abundant white or blood-tinged watery froth. This spreads away down into the bronchial tubes. It is due to violent respiratory efforts under circumstances in which only water can enter the air passages. Its presence therefore is a certain proof that the person was alive on entering the water. Its absence, however, does not prove the contrary, as the individual may, under circumstances already described, fail to make any effort to breathe after immersion. Further, the froth disappears shortly after death.

Lungs.—These are distended, filling the chest and protruding when the chest is opened. They have a soft, flabby feel, and are deficient in elasticity, so that the surface "pits" on pressure. They are much heavier than usual though they still float in water. On section a bloody frothy liquid escapes. There is also more or less congestion of the lungs. Sub-pleural ecchymoses may be present.

Heart.—If death has been due purely to asphyxia the right heart, lungs, and viscera generally are engorged with dark venous blood, whilst the left heart is either completely or partially empty. The condition of the heart, however, varies. The blood is venous in character and generally, but not always, fluid.

Stomach.—More or less water is frequently found in the stomach. The quantity is greatest in those who have struggled longest and most frequently risen to the surface. The power of swallowing is immediately suspended on the occurrence of asphyxia. In cases of individuals who have rapidly succumbed, or who have died from syncope, there may be no water in the stomach. If the fluid present in the stomach contains some chemical substance (salt, dye, etc.), or weeds similar to those present in the water in which the body is found, such evidence is of great value as a proof of drowning, as swallowing is of course a *vital* action. It is possible, it must be remembered, that water may have been taken freely shortly before immersion. In bodies too in which decomposition is advanced water may possibly gain entrance into the stomach. But otherwise water does not, under ordinary circumstances, pass into the stomach of a dead body thrown into water, as the œsophagus remains contracted and closed.

The most important of the *post-mortem* signs are :—The froth in the trachea, bronchi, etc.; the condition of the lungs; fluid in the stomach; plants, sand, mud, etc., grasped in the hands. The absence of evidences of any other cause of death must be determined. The characteristic signs, too, it must be remembered, soon disappear; in summer, in two or three days; in winter, in fifteen to twenty days. It is

important that the body be examined as soon after its removal from the water as possible.

The question of homicide, suicide, or accident is governed by other than purely medical evidence. Homicide by drowning is very rare. Children may be easily murdered in this way, but an adult would offer resistance. Hence evidences of struggle on the clothing or person of the deceased, or on the banks of the river, would be expected. A murderer may endeavour, by throwing the body of his victim into water, to suggest suicide by drowning. The *post-mortem* appearances of drowning in such a case would be absent, and the marks of violence on the body, or the presence of poison in the viscera, would indicate the real cause of death. All cases in which marks of violence, such as cut-throat, bullet wound, etc., are present on the body are not, however, necessarily homicidal. A suicide may inflict such injuries on himself, and then complete his purpose by drowning; or accidental drowning, especially if the person falls from a height, may be accompanied by marks of violence on the body due to striking against some projection on the banks of the river. The body, too, may be injured by being carried against large stones, trunks of trees, or other obstacles in the water. Even violent impact against the surface of the water, as in falling from a height, may produce considerable bodily injury. In supposed suicides the question of motive, evidences of design or purpose—such as weights attached to the body or placed in the pockets of the clothing—and the absence of all signs of resistance, are important considerations.

There is no doubt that death from drowning, and the characteristic *post-mortem* appearances of death from drown-

ing, can be produced by mere immersion of the face in water. This may occur from accident, as when under the influence of drink, or in an epileptic fit, an individual falls with his face in a shallow vessel or pool. Suicide may be committed in the same way, and so may homicide, but in the latter case (unless the victim is a child) the body will show evidences of resistance, and it is probable that more than one person has been concerned in the murder.

The time that a body has been in the water must be estimated by the degree to which putrefaction has advanced.

A dead body comes to the surface when, in consequence of the accumulation of the gases of putrefaction in the abdomen, etc., it is rendered specifically lighter than the water in which it is immersed. The exact time will vary with the temperature of the water as influencing the rate of putrefaction, the proportion of fat in the body, etc.; in this country the average is from five to eight days. As a rule, a body comes to the surface with the loins and buttocks uppermost, the extremities and head being below the surface; the bodies of females frequently float with the abdomen upwards.

Treatment of the apparently drowned.—Unless the person is undoubtedly dead, resuscitation should be attempted, for sometimes cases which appear to be hopeless recover. There is always a chance so long as the heart has not absolutely ceased beating. Every moment is of importance, and therefore action must be prompt and energetic. The first object is to try and re-establish respiration, and after this has been accomplished, to promote the activity of the circulation. The following is the line of procedure :—

1. Rapidly remove all articles of clothing from the neck and chest, and those assisting should take off all the wet clothes, dry the surface, and cover the body with blankets, overcoats, or anything that may be at hand.

2. Place a bundle of clothing under the chest and stomach, the body being placed face downwards, and press firmly over the back of the chest, so as to try and expel mucus and water from the bronchial tubes. This manœuvre is of great importance, because, unless the bronchial tubes are clear, artificial respiration will not secure the admission of air to the pulmonary air-cells.

3. Turn the body over on the back, placing a bundle of clothing under the shoulder-blades, wipe away the froth from the mouth and nostrils, and draw forward the tongue, and keep it in that position, so that there may be no mechanical barrier to the entrance of air to the respiratory passages. An elastic band, or a piece of tape, passed over the tongue and under the lower jaw will secure the tongue in the forward position.

4. At once commence artificial respiration, and continue it regularly and with perseverance.

5. As soon as there is evidence of voluntary respiratory effort, endeavour to stimulate the circulation and promote bodily warmth by friction of the limbs, rubbing towards the trunk; application of hot bottles to the surface; the administration of small quantities of stimulants by the mouth, if the patient can swallow. If these means are satisfactory, the patient may be allowed to rest and encouraged to sleep.

Methods of conducting artificial respiration.—There are several of these. The following may be noted:—

SYLVESTER'S METHOD.—Kneel behind the patient's head

and grasp the arms just above the elbows; then draw the upper limbs steadily towards you, so that they are stretched out beyond the head in a line with the body; this movement expands the chest, and represents therefore the movement of inspiration. Now, promptly carry the arms back again to the sides of the chest, pressing them firmly against the ribs, so as to compress the chest and imitate the movement of expiration. This procedure should be conducted at such a rate as to produce about fifteen complete movements per minute.

HOWARD'S METHOD.—The operator kneels astride the patient's body looking towards the head. He places his hands one on each side of the front of the chest, the thumbs hooked under the lower ribs, the fingers spread out over the surface, and his elbows rested in front of his own hips. He now leans steadily forward, so that the weight of his body through his forearms pushes the ribs upwards, and so expands the chest, and he maintains this condition for two or three seconds. Then, with a sudden push against the sides of the chest, he springs backwards and allows the ribs to descend, thus imitating the movement of expiration. This is a less wearisome method than Sylvester's.

MARSHALL HALL'S METHOD.—In this the operator kneels at the side of the patient, under whose shoulder-blades is a bundle of clothing. He then rolls the patient well over on to the side away from him, pressing on the side and back of the chest to represent the act of expiration. Then he promptly turns him on to his back again, which expands the chest and represents inspiration. The movement of the chest so produced is not so free as in the other methods,

but as the strain upon the operator is slight, he can keep up the movements for a long time. It is therefore of value when there is little or no assistance to be obtained.

LABORDE'S METHOD.—This consists in rhythmical traction of the tongue. The tongue is seized and alternately drawn forwards and relaxed at about the rate of the normal respiratory rhythm. It is suggested that the respiratory centre is reflexly stimulated by this means. Sighing, vomiting, and hiccough may be produced.

Hanging; Strangulation; Throttling.—In each of these forms of violent death there is pressure on the trachea, etc., so as to produce more or less complete obstruction to the entrance of air to the lungs. In both hanging and strangulation the pressure is applied by means of a ligature round the neck. The force which makes the ligature tense in the case of hanging is the weight of the body; in strangulation it is some external force which pulls the cord tight. Throttling is usually caused by compression of the trachea by the grasp of a murderer's hand. *Suffocation* is the production of asphyxia by mechanical means other than the above. (See p. 45.) In the above three forms of death there is pressure on the larynx and trachea (interfering with respiration) and on the large vessels in the neck (producing cerebral congestion). In judicial hanging, as at present practised in this country, there is generally dislocation of the cervical vertebræ—usually between the second and third—with resulting compression of the spinal cord.

If the violence applied to the neck is sufficient to completely prevent the entrance of air into the lungs, death will be by *asphyxia*. Should some air still gain admission, the

compression of the vessels of the neck may yet be sufficient to produce cerebral congestion and *coma.* Often the *post-mortem* appearances indicate that both these influences have combined to cause death. In some cases death may be due to *shock.*

General external post-mortem appearances.—The face is generally pale, though in plethoric persons and in those criminally executed it may be congested; the eyes may be protruding; the tongue either may or may not be driven forward between the teeth (this depends on the presence or absence of congestion, and not on the relation of the position of the ligature to the larynx); the hands are clenched, at least in violent hanging; congestion of the genitals, and, in the male, the discharge of semen may occur; the flow of saliva in a vertical line down the chin and chest has been regarded as supporting the theory that death has been caused by hanging.

The mark on the neck.—This may be a mere depression without discoloration. In some cases there is discoloration from ecchymosis. The ecchymosis is always superficial and slight; it does not extend into the deeper layers of the skin or the subcutaneous tissue. The most common condition, however, found in the depression produced by the rope is a hard, brown, state of the skin, which has *the colour and consistency of parchment.* These marks are no proof that death is due to hanging. They may be produced by suspension of a dead body, hours or even days after death. The brown mark last described is simply the result of mechanical compression of the skin. The width of the mark will, of course, vary with the breadth of the rope or cord. A wide ligature causes a wide and superficial mark; a thin cord, a

deep and narrow one, with possibly some laceration of the skin. A smooth soft ligature may fail to leave any mark.

In *strangulation* the mark is, as a rule, all round the neck and at about the same level; frequently it is at or below the level of the thyroid cartilage. In *hanging* the mark is generally present in front and absent behind, or present at one side and absent from the other; it is not all at the same level but is oblique, usually in front between the hyoid bone and the thyroid cartilage, and thence running on each side obliquely upwards behind each ear. If the knot should happen to be in front, the mark may be circular. The marks in *throttling* are of the same nature, but correspond to the grip of the thumb and fingers. They are thus on the sides of the throat; distinct scratches may be produced by the murderer's nails.

Injuries to the deeper structures of the neck are only likely to occur when hanging is produced with considerable violence. In such cases muscles may be torn, there may be fracture of the hyoid bone or larynx, and dislocation or fracture of the cervical vertebræ. Sometimes the inner and middle coats of the carotids are cut through. This may occur too without much violence. All of these effects may be produced by hanging up a dead body, and therefore their existence is no proof of death from hanging. If, however, there is extravasation of blood, especially if in considerable amount, it is almost certain that suspension took place during life.

Internal post-mortem appearances.—These will vary with the immediate cause of death. In asphyxia there will be the usual engorgement of the lungs, right heart, and venous system, with dark fluid blood. The mucous membrane of

the trachea is congested, and may present a fine froth on the surface. The blood vessels of the brain are congested, and this will be specially marked when death has been due partly or entirely to coma. In some cases distinct redness of the mucous membrane of the stomach has been observed. A similar appearance may be detected in some cases of death from drowning This might possibly be regarded as the result of an irritant poison, and so lead to serious error.

There are therefore no *post-mortem* signs which are absolutely distinctive of death by hanging. The appearances of asphyxia occur in many forms of death, and the mark on the skin may be produced by suspension of a dead body. If, however, there are in this mark distinct ecchymoses, and still more if there are extravasations of blood in the deeper tissues, the body must have been hanged either during life or very shortly (a few hours) after death. The absence of signs of any other cause of death, and *post-mortem* appearances consistent with death from hanging, may be sufficient, with circumstantial evidence, to decide that death was really due to hanging.

Was death the result of homicide, suicide, or accident?— The decision of this question may be assisted by medical evidence. *Hanging* is probably suicidal; next to drowning, hanging is the most common form of suicide. It is certain that complete suspension of the body is not necessary to cause death by hanging; the weight of the upper part of the body is quite sufficient to procure a fatal result. The absence of signs of struggle, with evidence of motive and design, would confirm the theory of suicide. Wounds, injuries, etc., present in a body found suspended by the neck, would be presumptive of homicide, but even these, unless

hey certainly could not have been self-inflicted, may have been due to previous suicidal efforts. A child, or feeble adult, might be murdered by hanging, but with an adult of ordinary strength it would be almost impossible unless there were two or more murderers. But a murderer may hang up the body of his victim in order to suggest suicide. *Strangulation* is in all probability homicidal, though suicide by strangulation occasionally occurs among the insane; anything like evidence of severe violence to the neck would be strongly against the theory of suicidal strangulation. *Throttling* is certainly homicidal, as a person compressing his trachea with his own hand would become unconscious and involuntarily let go his hold before death occurred.

Strangulation; Throttling.—The *post-mortem* appearances have the same general character as in hanging. But, as a rule, there is much greater injury done to the structures in the neck in consequence of the extreme violence which the murderer applies. For the same reason congestion of the face, and protrusion of the eyes and tongue, are marked. Sub-conjunctival, and cutaneous ecchymoses in the face, neck, and chest are common; a bloody froth is found in the air-tubes; and in the lungs rupture of the air-cells, and extravasation of blood may be detected. These appearances could not be produced by the application of a ligature or by manual pressure to the throat of a dead body.

Suffocation.—The production of asphyxia by mechanical means other than those already described, *e.g.*:—Closure of the mouth and nostrils as by application of a hand, bed-clothes or the like (smothering), mud, dust, etc.; closure of

the mouth and nostrils, combined with pressure on the chest, as in overlying; prolonged pressure on the chest as may occur in crowds; accidental or wilful introduction of foreign substances into the throat, larynx, etc.; swelling or spasm of the glottis from the irritation of corrosive substances. Death produced by the breathing of carbonic oxide, carbonic acid gas, and other irrespirable gases, is commonly spoken of as death from suffocation; more strictly speaking it is death from poisoning.

The post-mortem appearances in cases of mechanical suffocation will be those of asphyxia, with or without external marks due to violence. In the absence of such marks it may be difficult or impossible to state positively the exact cause of death. But the absence from the body of all signs of any other cause of death, with *post-mortem* evidences of asphyxia, will justify the statement that the appearances are consistent with death from suffocation. The existence of sub-pleural ecchymoses would very much strengthen this position. It must be remembered further, that the absence of signs of asphyxia may be quite consistent with death by suffocation. When death is rapid there may be no engorgement of the right heart or viscera. An overlaid child, for example, may present no lividity or other evidence of asphyxia, and nothing to positively show the cause of death.

Suffocation is not a form of homicide in adults (unless weak, intoxicated, etc.), but children may be comparatively easily suffocated. It may in some forms be due to accident, and rarely to suicide.

Carbonic-oxide Poisoning.—This results from the inhalation of the fumes of burning charcoal. It is frequently adopted as a means of suicide in France. The most

haracteristic *post-mortem* appearance is an undue redness f the blood and muscles, due to the formation of carbonic-xide-hæmoglobin. The presence of this substance in the lood is indicated by:—(1) The persistence of the florid olour for days and even weeks; (2) the spectroscope, hich shows two dark bands, and these under the influence f reducing agents are *not* replaced by the single band haracteristic of reduced-hæmoglobin. The two bands of ne oxy-hæmoglobin spectrum are replaced by a single band hen the blood is treated with reducing agents (see p. 87).

In all persons poisoned by charcoal fumes the blood is ot unduly red; it may indeed be unduly dark. This is ue to the fact that the burning of charcoal produces car-onic acid gas as well as carbonic oxide. Carbonic acid gas akes the blood dark and venous in character, and hence he actual appearance of the blood will vary with the pro-ortions in which the two gases are absorbed.

Coal-gas Poisoning.—The principal poisonous agent in oal-gas is carbonic oxide. The patient is usually found in n unconscious condition, the face flushed, the pupils con-racted or dilated but responding to light, and the odour of he gas present in the breath; sometimes there are convul-ions. He may die without recovering consciousness, or nay improve for a time and subsequently relapse into coma.

Treatment.—Removal of the patient into fresh air, artifi-ial respiration, and the inhalation of oxygen; warmth to he surface, and stimulants to counteract the collapse. In ome cases venesection has been performed, followed by ransfusion of blood. This practice is suggested by the fact hat the carbonic-oxide-hæmoglobin being a stable com-ound, there is little chance of getting a proper quantity

of oxygen into the blood, the hæmoglobin being firmly associated with the carbonic oxide. Hence new blood is needed to take up oxygen at the lungs and to carry it to the tissues.

Post-mortem examination shows congestion of the brain and lungs, the blood here and elsewhere having a bright red colour.

Wounds.—There is no legal definition of the term *wound;* but, as used by medical jurists, it has a wider application than as employed by surgeons. It is not necessary that an injury should be attended by a breach of surface to constitute it a wound in the legal sense of the term. Thus, a simple fracture, a dislocation, an effusion of blood on the brain (without division of the skin) the result of a blow, have all been held by legal decisions to be wounds. Taylor proposes the following definition :—A wound is a breach of continuity in the structures of the body, whether external or internal, suddenly occasioned by mechanical violence. A medical witness is frequently called upon to answer the question whether a particular wound is or is not *dangerous to life*. In doing so, he must use his own judgment, and must be prepared to give reasons for the opinion he expresses. But he should not regard the wound as dangerous to life unless the danger is *imminent*, as for example, in a wound of a large artery, or of one of the viscera. There is, of course, a chance that even a slight wound may become dangerous in consequence of the supervention of erysipelas, septicæmia, tetanus, etc.; but the danger here is *remote*, and it would be incorrect, merely on the chance that such complications are possible, to describe a wound

as dangerous to life. The term *mortal* wound implies a wound which, in spite of the best medical assistance, must necessarily prove fatal.

Examination of Wounds.—In examining a wound on a dead body, the situation, extent, length, breadth, depth, and direction should be noted; whether there is about it effused blood, either fluid or clotted; and whether there is ecchymosis or not. It should also be ascertained whether the surrounding parts are swollen; whether any adhesive matter or pus is effused; and whether the edges of the wound are gangrenous, or any foreign substances are present in it. Care must be taken not to mistake putrefaction for gangrene. (Taylor.) The exact tissues and organs injured must be observed, and this must be determined by dissection, using such an instrument as a gum-elastic bougie as a guide or director. If there are more wounds than one, each is to be examined in the same careful manner, and the witness must be prepared to give a reasoned opinion as to which of the wounds (if any) caused death. He should also make a complete *post-mortem* examination of the body—otherwise it may be suggested, if the case is one involving a charge of criminal violence, that disease of some organ caused, or contributed to cause, death. It may be necessary in some cases even to examine the contents of the stomach for the presence of poison.

All notes should be made at the time of the examination, and the report on the case should be expressed in simple and non-technical language. The witness should (if possible) give a definite opinion on the question whether the injuries found were or were not the cause of death. Difficulty may arise when the examination reveals some

internal disease; but, even though this exists, and would probably soon have proved fatal, the person who inflicted the wound—if the wound has accelerated the death of the deceased—is still held legally responsible.

A wound may be *directly* fatal—that is, may cause death at once or soon after its infliction, either from (1) hæmorrhage, (2) great mechanical injury to some vital organ, or (3) shock. In connection with the latter, it should be remembered that fatal shock may follow such causes as severe fright, blows on the epigastrium, etc., and that in such cases *post-mortem* examination may fail to detect any evidences of injury. Death from concussion of the brain may similarly fail to leave manifest *post-mortem* changes.

Secondary, or *indirect*, causes of death from wounds are septicæmia, erysipelas, gangrene, tetanus, etc., and the medical witness may be called upon to express an opinion as to how far these results were unavoidable, or to what extent they were due to unskilful treatment or to carelessness on the part of the deceased himself.

When, in a case of wounding, a surgical operation is performed, and the patient dies, it is frequently suggested on behalf of the accused that the operation was the cause of death. But if it can be shown that the operation was absolutely necessary (and to strengthen this decision it is wise, if possible, to act only after consultation with one or more surgeons), that it was performed with reasonable care and skill, and that the wound was from the beginning a dangerous one and liable to cause death, the law regards the operation as one of the necessary consequences of the wounding, and the accused is held responsible for the death. In *England* a man cannot be tried for murder if

his victim survive the injuries for more than a year and a day.

Distinction between Ante-mortem and Post-mortem Wounds.—If there are evidences of commencing cicatrization, of purulent exudation, of gangrene or sloughing, or of swelling and infiltration of the edges of the wound, it will, of course, be manifest, not only that the wound was inflicted before death, but also that it was inflicted some time before death. On the other hand, a wound inflicted some time (say ten or twelve hours) after death, has distinctive features of its own (see below). But a wound inflicted *immediately after* death has much the same characters as one inflicted *immediately before* death, and it may be impossible for the medical witness to do more than say of a certain wound that it was produced either during life or immediately after death. This, however, may be valuable evidence, as the infliction of violent injury upon a dead body shortly after death, except by a murderer, is scarcely conceivable.

Characters of a wound inflicted shortly before death:—

1. Abundant hæmorrhage—usually of an arterial character and the blood clotted—found in the wound and on surrounding objects.

2. Muscles and cellular tissue reddened by effused blood.

3. Eversion of the edges and gaping of the wound from vital retraction of the skin and muscles.

It is punctured and incised wounds which present these features to the most marked extent; lacerated and contused wounds do not, as a rule, give rise to much bleeding, even when they involve a large blood-vessel. Thus an entire limb may be torn from the body, as in a machinery accident, with very little bleeding, the twisting and contraction of the

arteries, which become retracted in their sheaths, preventing free hæmorrhage. On the other hand, a lacerated wound inflicted shortly *after* death may cause rather free bleeding. A contused wound will, of course, present evidences of ecchymosis, and the recognition of this as an *ante-mortem* event will be determined by the same considerations as guide the decision in cases of contusion. (See p. 63.)

In connection with fractures, evidences of callus formation, or of inflammatory effusion, indicate distinctly their *ante-mortem* character. If produced very near the time of death, it may be difficult to distinguish an *ante-mortem* from a *post-mortem* fracture. A considerable effusion of blood would favour the former.

Characters of a wound inflicted ten to twelve hours after death :—

1. Little or no hæmorrhage, or, in consequence of division of a large vein, some free bleeding—the blood, however, being venous in character and not clotted.

2. No infiltration of muscles and cellular tissue with blood.

3. Edges soft, yielding, and not everted—*i.e.*, the edges of the wound are in contact, and the wound is not gaping.

Evidence of the use of a Weapon.—Proof that a weapon has been used may be of considerable importance in a case of criminal wounding, as the use of a weapon (as a rule) implies a greater degree of malice on the part of the accused. Cuts and stabs, by their regularity and their clean-cut edges, are generally easily recognised as produced by some sharp instrument, the stab being distinguished by its depth. A punctured wound, due to a knife or other sharp instrument, will have a regular and even edge ; but if from broken glass

or earthenware, the edges are likely to be lacerated and irregular, and the wound will probably contain some pieces of the foreign body. A stab, in consequence of the elasticity of the skin, may appear to be smaller than the instrument by which it was produced. If a stab pass right through a part, the aperture of entrance will usually be larger than that of exit, and its edges may be everted by the rapid withdrawal of the instrument.

Lacerated wounds usually give distinct evidence of the mode of their production—they are generally due to accident.

It is in the case of contused wounds and severe contusions that the main difficulty is experienced in determining whether or not a weapon has been employed, for such injuries may follow a blow with the closed fist or with some blunt instrument, or may be caused by a fall. This difficulty comes up more especially in cases where death is due to injury to the head, and the suggestion of the defence is that the injury is the result of the deceased falling and striking his head against some hard substance. It may be impossible to give a confident opinion, but such circumstances as the following are of assistance:—A number of contused wounds on various parts of the head suggests the use of a weapon; evidences of violence over the upper part of the head point in the same direction; the presence in the wound of such foreign bodies as sand, gravel, etc., on the other hand, renders the theory of a fall more probable. It must be remembered, too, that a blow, even with a blunt instrument, over a subcutaneous bony surface—*e.g.*, the skull—may produce a wound with rather a clean-cut appearance. Careful examination, however, will usually

detect some irregularity of the edges, and evidences of contusion round the wound.

The medical witness, having expressed an opinion that a weapon has been employed, may further be asked to say what kind of a weapon has inflicted the injuries which are the subject of investigation; or, when a weapon is produced in court, he may be called upon to say whether such a weapon could have produced the wound or wounds. He cannot, of course, swear to a particular instrument, but can express an opinion as to the degree of probability in the suggestion which is made to him.

An examination of the clothing may sometimes reveal distinct evidence that a weapon has been used; though, when this is of a blunt nature, considerable injury may be inflicted on the body without perceptible damage to the clothing. Any marks on the clothing suggesting violence should be carefully compared with the bodily injuries—the two may or may not correspond.

Is the Wound a Suicidal, Homicidal, or Accidental one?—This question may be determined by other considerations than medical ones; but in doubtful cases the medical witness may lend important aid in the decision. The most important points to observe are connected with—(1) the situation of the wound; (2) its nature and extent; (3) its direction.

1. SITUATION.—Suicidal wounds are usually found on the front or lateral aspects of the body, in regions readily accessible to the individual himself, and in parts commonly recognised as vital. A wound in the back is probably, but not certainly, homicidal; its direction will be of prime importance in determining between suicide and homicide.

All situations are accessible to the homicide, and he may purposely, in order to avoid consequences, inflict a wound suggestive of suicide. Wounds in concealed situations—*e.g.*, the vagina—suggest homicide. Accidental wounds are generally, but not invariably, on exposed parts. Insane persons sometimes inflict wounds upon themselves in very unusual situations; and in every case, great care must be exercised before giving a positive opinion that a wound is certainly not self-inflicted.

2. NATURE AND EXTENT.—Suicidal wounds, excepting those inflicted by fire-arms, are usually cuts or stabs. There may, however, be severe contused wounds, as when a suicide throws himself from a considerable height. The insane, too, sometimes inflict severe contusions and lacerations on themselves. A homicide may inflict any kind of wound. When there are contusions thus produced, a frequent defence is that these are accidental, and the result of a fall. The fact that some of the injuries are in situations inconsistent with the idea of a single fall—*e.g.*, on opposite sides of the body—will negative such a suggestion; and evidences of violence in such situations as the inner sides of the arms and thighs, point in the same direction. Accidental wounds may be of almost all kinds, but an incised wound on a vital part can scarcely be accidental. Stabs, however, are not infrequently the result of accident—as when a man falls with a weapon in his hand, etc.

When two or more wounds of a severe nature, not due to accident—*e.g.*, a fall—are found on a dead body, the case is probably, though not certainly, one of homicide. Yet a suicide has been known to shoot himself first in the head and afterwards in the chest, and a man who has cut his

throat may complete his self-destruction by throwing himself from a height. Slight wounds, in addition to the one which has caused death —*e.g.*, superficial cuts on the neck in a case of cut-throat—may be due either to movements on the part of the victim when attacked, or to the preliminary attempts of a hesitating suicide.

Direction.—In suicidal stabs the direction is commonly from right to left (unless the man is left-handed), whilst a stab inflicted by a homicide passes from left to right (unless the assailant stabs his victim from behind). As regards the vertical direction, a stab passing obliquely from above downwards may be the act either of a homicide or a suicide; whilst one passing from below upwards is almost certainly not suicidal. Provided that there is no question of accidentally falling on some pointed instrument, such a direction very strongly suggests homicide.

In cases of cut-throat, when suicidal, the incision (unless the man is left-handed) is carried from left to right, and passes either horizontally or, as is more usual, obliquely from above downwards, though this may be exactly imitated by a homicide who attacks his victim from behind. There are other considerations which may aid in the distinction between suicidal and homicidal cut-throat. A suicide usually inflicts the cut upon the upper part of the throat, either above or through the thyroid cartilage, so that, whilst the larynx is opened, the larger blood-vessels escape, or only those on one side are divided. A very extensive division of the structures in the neck, though not usual, may, however, be the act of a suicide. If, however, there are distinct cuts on the bodies of the cervical vertebræ or on the intervertebral substance, the case is almost certainly

one of homicide. Homicidal incisions are often prolonged below and behind the skin forming the angles of the wound, deeply into the soft parts. Those which are suicidal rarely possess this character; they terminate gradually in a sharp angle, and the skin itself is the furthest point wounded; the weapon is not carried either behind, below, or beneath it. (Taylor.) Recent cuts on the hands, giving evidence of resistance, strongly suggest homicide; but even here there is room for error. In a case of suicidal cut-throat, blood is usually found on one or other of the hands.

Certain other considerations which may assist in distinguishing cases of homicidal from suicidal wounding may be briefly alluded to.

Position of the Body.—This should be carefully observed; it may be quite inconsistent with the theory of suicide. Thus it may be found doubled up in a box.

Position of the Weapon.—In the case of a self-inflicted wound which must have been rapidly fatal, the weapon may be found firmly grasped in the hand of the deceased (cadaveric spasm), or may be lying near to the body. Should the weapon (presuming it is the one by which the wound has been caused) be found in a situation where the deceased could not have placed it after the infliction of such a wound, the case is manifestly not one of suicide; and the same inference is usually justified when the weapon cannot be found.

It is necessary to compare the weapon with the wound, and to examine it thoroughly for blood-stains, hairs, etc. It is quite possible that a stab, and even a fatal stab, may be inflicted, and the instrument have little or no blood on it—being, as it were, wiped clean as it is withdrawn.

Marks of Blood.—The relation of the escaped blood to the body may indicate the position which the deceased was in at the time of the infliction of the wound. This may be of great importance. Thus, suicidal cut-throat is very rarely attempted in the recumbent posture; if then in a case of cut-throat the blood is found, not down the front of the body, but on one or other side of the neck, the probability is in favour of homicide. Again, the body may be so far away from the main pool of blood as to be inconsistent with the idea of suicide. Marks of blood on furniture, etc., may give evidences of a struggle, or in the form of footprints may help to trace the murderer. The absence of blood-stains from the clothes of an accused person is no proof of innocence; a murderer may, *e.g.*, cut his victim's throat from behind, or he may have had time to change his clothing, or to remove the stains. On the other hand, stains of blood may in various ways come to exist on the person or clothing of an individual quite innocent of crime.

Clothing.—The clothing of the deceased may throw some light on the question of suicide or homicide. It may, for example, give evidences of a struggle having occurred. Again, if, in death from an incised or stabbing wound, the clothing is cut, there is a presumption of homicide, as a suicide usually removes what would be likely to interfere with his purpose.

Such points as are above alluded to should be carefully observed by the medical man, as he is frequently one of the earliest persons to see the dead body; and no disturbance of the body should be permitted until a careful note of its position and its relation to surrounding objects has been made.

IMPUTED OR SELF-INFLICTED WOUNDS.—Wounds may be self-inflicted for various reasons, such as to suggest resistance to a robbery of which the wounded man has himself been guilty; to support a theory of provocation in a case of murder, etc. Such wounds are usually superficial, are generally numerous, and are always in parts accessible to the individual himself. The hands are not severely wounded, as is often the case when resistance is offered to a homicidal attack. Severe injuries may be inflicted on the clothing, and if these do not correspond to the injuries on the person, the theory of self-infliction is strongly suggested. Self-inflicted wounds are almost always cuts or stabs.

Gun-Shot Wounds.—Wounds inflicted by fire-arms are usually easily recognised. The projectile may be found in the body, the clothes or skin may be singed by the explosion of the gunpowder, or both an entrance and an exit wound may be present. A stab, if it penetrates the body, produces two wounds, but the track connecting these is quite different from that due to the passage of a bullet. This destroys the vitality of the part it strikes, and so leads to sloughing in its track. In rare cases lightning has been known to produce wounds similar to those caused by a bullet.

The appearances of wounds produced by fire-arms vary according to the nature of the projectile, and to the distance from which it is fired. A charge of small-shot fired point-blank from a distance of 10 to 12 inches causes a round opening something like that due to a bullet; from a distance of 18 inches it makes an irregular opening with lacerated margins; at 36 inches there is no central opening, but the shot are scattered widely over the surface of the body. A

charge of shot fired close at hand is even more dangerous than a bullet, because the shot produce extensive lacerations. A conical bullet is more liable to pass through the body and to produce smaller wounds, than a round ball, other things being equal. A gun loaded with gunpowder and wadding, or even with gunpowder alone, if fired near at hand, may cause even a fatal wound; some part of the powder escapes combustion, and each unconsumed particle acts like a small pellet.

A gun-shot wound may produce immediate death by shock, or from hæmorrhage if a large blood-vessel is opened. If the patient survive the immediate effects, he is liable to the usual risks which attend wounds, and as the parts in the neighbourhood of the track of the bullet are bruised, there is always more or less sloughing, and therefore a special risk of septicæmia and of secondary hæmorrhage. It is not always easy to say whether the wound was inflicted shortly before or soon after death, unless a blood-vessel has been opened. The existence of considerable hæmorrhage, and the presence of clots, indicate an *ante-mortem* wounding. In a dead body, however, blood may be effused if the bullet lacerates a large vein.

The question as between suicide or homicide is to be decided by considering whether the weapon was discharged near to, or at a distance from, the body, and also the direction from which it was fired. Suicides usually use pistols and fire at some vital part; manifestly the wound will have the characters of one inflicted close to the body, and the pistol may be found firmly grasped in the hand. If a gun is employed by a suicide, evidences of suicidal design are usually conspicuous.

If a conical bullet is fired into the body from *close at hand*, there may be two apertures, the one of *entrance* the other of *exit;* but this is by no means an invariable rule. The clothing and the skin will be blackened and singed by the powder; the aperture of entrance may be round or oval; bleeding is usually more abundant from the aperture of exit, which is about the same size as the entrance wound. If smokeless gunpowder has been used, there may be scorching of the skin, but no blackening from smoke or unconsumed particles of powder.

When the gun is discharged at *some distance* from the body, the entrance wound will be round or oval, with well-defined edges, which may be inverted; around it a slightly-bruised appearance is detected, but no blackening or singeing of the skin. The exit wound is usually three or four times larger, is irregular, has lacerated margins which are everted, and from it blood will probably have escaped.

A conical bullet fired from a modern rifle and travelling with fair velocity, rather cuts than crushes its way through the tissues; it splinters rather than smashes the bones; and the entrance and exit wounds may be difficult to distinguish.

Examination of the clothing may assist in distinguishing the entrance and exit wounds—the latter in the clothing is always large and ragged, while the aperture of entrance is small, and may, indeed, appear smaller than the bullet.

A decision as to the entrance and exit wounds, with a study of the track of the ball, will give a clue to the direction from which the ball has been fired.

Accidental shooting almost always occurs close at hand, and presents no evidences of design.

Examination of Fire-arms.—It is impossible to say

definitely from an examination of a pistol or gun the length of time that has elapsed since it was fired. But, if discharged *recently*, the barrel of the piece will have adhering to it a quantity of potassium sulphide mixed with charcoal, and this will give an alkaline solution, with an odour of sulphuretted hydrogen, and yielding a blackish-brown precipitate (lead sulphide) on the addition of lead acetate. After a varying time the potassium sulphide will be converted into potassium sulphate, and the washings of the barrel will form a neutral solution, which will yield a white precipitate (lead sulphate) with lead acetate.

Ecchymosis from Violence.—Blows with a blunt weapon may produce contusions or contused wounds. These are evidenced by the occurrence of ecchymosis—*i.e.*, a bluish-black or livid-red discoloration of the skin due to the extravasation of blood from the rupture of small vessels. The bruise may appear almost immediately, or only after an interval, and it may be, that violence inflicted shortly before death may lead to the appearance of a bruise only after death. The situation of a bruise, in consequence of the gravitation of the blood downwards, may fail to correspond to the site of the violence. Bruises are late in appearing in regions where the subcutaneous tissue is dense. It must be remembered that considerable violence may have been applied to the body, and much internal injury, even rupture of the viscera, inflicted, and yet no superficial bruising occur. On the other hand, some people present considerable ecchymosis after the application of a very slight amount of violence, and bruising may even follow severe muscular exertion.

The changes which a bruise undergoes in colour may assist

in determining approximately the time when the injury was inflicted. The bruise is at first bluish-black, in some eighteen to twenty-four hours it has a violet tint, and in the course of three days or so it passes successively through a greenish to a yellow colour, discoloration of the skin during the earlier part of these changes becoming more widely spread. The changes in colour proceed inwards from the circumference, so that the central part of the bruise is always darker than the marginal part. The rate of their progress varies with the size of the bruise, the density of the subcutaneous tissue, and the age of the person, being more rapid in young people.

The existence of ecchymosis is not certain proof that the violence was applied during life, as bruises may be produced shortly *after* (say within two or three hours after) death by using extreme violence, and bruises so produced closely resemble those caused shortly *before* death.

Distinction of Ante-mortem from Post-mortem Bruises.—As just mentioned, this is sometimes difficult. If there is distinct swelling of the part (inflammatory effusion), and the bruise shows change of colour at its margin, it must have been produced some hours or days before death. Further, if the blood below an ecchymosis is clotted, or even if there is a considerable amount of liquid blood but no injury of a large vein from which it could have escaped, the bruise is almost certainly an *ante-mortem* one. In a *post-mortem* bruise, there will be little extravasation unless a large vein has been torn through.

Cadaveric Lividity or Hypostasis.—This must not be mistaken for ecchymosis, the result of violence. It presents itself in the form of livid patches, which develop as the body cools and whilst the blood is still fluid. The patches form

chiefly on the most dependent parts, but not on those which are subjected to pressure. They are due to gravitation of the blood into the capillaries of the most dependent parts. They are seen not only in the skin, but also over the posterior parts of the pia mater, lungs, intestines, etc. Their uniform purplish colour, the well-defined edge, and the fact that no effusion of blood into the skin or subcutaneous tissue is found on incision into the patch, distinguish them from bruises.

Livid patches may be seen during life in elderly persons with weak circulation; they are superficial, and can scarcely be mistaken for bruises. The ecchymoses of *purpura* and *scurvy* are distinguished from those due to violence by the other symptoms which accompany these diseases.

Note I.—Blood coagulates much more slowly in the dead body than when withdrawn from the blood-vessels. It may remain fluid from four to eight or even twelve hours after death.

Note II.—The phrase *wounding to the effusion of blood*, in the law of Scotland, implies the actual shedding of blood from an external wound.

Rape.—Rape is the carnal knowledge of a woman by force and against her will, or of a girl under 13 years of age whether by force or not. Carnal intercourse, *with consent*, with a girl between the ages of 13 and 16, though not rape, is a legal offence, and is punishable by imprisonment under the Criminal Law Amendment Act of 1885. After the age of 16, consent on the part of the woman removes criminal responsibility. Mere penetration to the vulva is sufficient to constitute an act of rape. It is not necessary to prove penetration to the vagina or rupture of the hymen. Neither

is the emission of semen necessary, though when this occurs it may afford valuable evidence of the crime.

The medical witness may be called upon to examine either the complainant or the accused. The examination must not be made without the consent of the person concerned, or, in the case of a child, of its legal guardians. The accused, too, cannot be examined, as far as his generative organs are concerned, without his consent, and he must be previously warned that the results of the examination may possibly be used as evidence against him. Great care is necessary in examining a female making a charge of rape. There are many opportunities for fallacy, and such charges are made not infrequently without foundation. It is well that the woman be given no time for preparation, and the practitioner should always make a careful note of the date, hour, and facts of the examination. The following are the principal points to be observed :—

1. *The General Strength, Vigour, and Intelligence of the Woman.*—It is improbable that intercourse could be accomplished against the consent of a healthy adult, unless she had been first rendered more or less helpless by violence or by the use of narcotics or anæsthetics. She may, however, faint, or become helpless from terror, and may thus be unable to offer resistance; or her resistance may be overcome by two or more assailants, in which case marks of violence are to be expected on various parts of her body; or she may yield under threats of physical force. Rape has been committed on a married woman when asleep, but this, improbable in any case, would be impossible in a virgin, unless limited to slight vulval penetration. There is no doubt that pregnancy may result from an act of rape.

2. *The Existence of Injuries indicating Resistance.*—These may be found in the shape of scratches or bruises on the wrists, breasts, front of the body, thighs, etc. It should be observed whether the appearances of such injuries are consistent with the date at which they are said to have been inflicted. The state of the clothing may indicate that a struggle has taken place. The body of a child seldom presents marks of violence, as young children do not usually offer much resistance; bruises, however, may exist on the lower limbs. Self-inflicted injuries are as a rule slight and superficial, and in regions easily reached by the woman herself. In the case of a child, injuries may be inflicted by the mother or other person with the object of supporting a false charge of rape.

3. *External Genitals.*—If there are no marks of violence on the genitals it is impossible to say there is *medical* evidence that rape has been committed. At the same time, the absence of such evidence does not prove that rape has *not* been committed. Thus, a woman accustomed to sexual intercourse may be ravished without any local injury of the vulva; or the signs of violence may have had time to disappear before the examination was made. On the other hand, violence may be purposely applied to the genitals in order to support a false charge of rape.

The appearances suggestive of recent rape are hæmorrhage, bruising of the external parts, abrasion or laceration of the mucous membrane, and, in from twenty-four to forty-eight hours, signs of inflammation—pain (aggravated on walking and by micturition and defæcation), tenderness, swelling, and muco-purulent discharge. In a virgin who has reached puberty, hæmorrhage—from injury of the vessels

of the hymen—is to be expected, whilst in a young child there may be no hæmorrhage, in consequence of failure to accomplish full penetration. The bruising, laceration, and subsequent inflammation, on the other hand, are likely to be more marked in a child, and there may be even rupture of the perinæum or vagina. In women habituated to sexual intercourse, local evidences of violence to the genitals may be absent or slight. Under the same circumstances the signs of violence soon disappear, and in adults, generally, they may fail to be detected after a few days; in children they are more persistent, lasting from seven to fourteen days, but varying in this respect according to their severity.

In reference to the existence of discharges from the genitals, it must be borne in mind that the woman may be suffering from leucorrhœa, and that it is by no means uncommon for unhealthy children to have a discharge from the vagina. The mere occurrence of a purulent discharge, therefore, unless it is accompanied by signs of actual violence, must not lead the practitioner to conclude that a rape has been accomplished. Care, too, must be taken not to mistake the malignant ulceration known as *noma* for the results of criminal violence.

4. *Vagina and Hymen.*—The vagina may or may not be dilated; in children it is sometimes lacerated. There may be evidences (in the virgin) of recent rupture or laceration of the hymen, the margins of a recent laceration being sharp, not thickened, and tender. As already explained, rape does not demand rupture of the hymen, and if full penetration has not been accomplished (and this is not uncommon in children), it may entirely escape damage.

5. *Semen and Seminal Stains.*—The pubic hair and

vulval mucus must be examined for spermatozoa, and the linen for seminal stains. These, as usually found in the dried state, have the following features :—(1) They give the fibre of the stuff a stiffened character; (2) have a dull whitish colour, with a slightly translucent appearance; (3) communicate a gummy sensation when handled between the finger and thumb; (4) take on a yellowish tinge when heated; (5) are free from smell, but, when moistened with warm water, acquire a faint, peculiar odour; (6) moistened with a small quantity of water, and a little of the water squeezed on to a glass slide, are found by the microscope

Trichomonas Vaginæ, magnified 680 diameters. *

to contain spermatozoa. The spermatozoon is recognised by its pear-shaped head (about one-third the size of a red blood corpuscle), and by its long filamentous tail. It must not be confounded with shreds of linen or with the *Trichomonas vaginæ*, a microscopic animalcule found in certain morbid states in the vaginal mucus. The head of this is granular, about three times as large as the head of the spermatozoon, and possesses cilia; the tail, too, is much shorter.

In the *examination of the accused* the medical witness may note :—

1. His general strength as compared with that of the complainant.

* Copied by permission from Dr. Luff's *Text-book of Forensic Medicine and Toxicology*.

2. The condition of the clothes, which may give evidence of resistance, or may be soiled by mud, dust, etc., if the act has been committed on the ground.

3. Any marks, scratches, etc., which the woman may have caused in resisting him.

4. The condition of the penis with regard to the existence of gonorrhœa, or venereal sores. Sometimes rape is committed on young children under the belief that coitus with a virgin will cure venereal disease; and the existence of gonorrhœa, both in the complainant and accused, would be presumptive, though by no means conclusive, evidence of guilt. A gonorrhœal discharge in the female does not appear until several days (3 or 4) after coitus; it is usually much more abundant than a discharge the result of violence inflicted by an act of rape, and it persists much longer. "A statement on oath as to the gonorrhœal nature, or not, of a discharge from the presence or absence of gonococci, is not justifiable in the present state of bacteriology."—(Luff). Leucorrhœal discharges often exist without marked redness of the mucous membrane or other signs of acute inflammation.

5. The state of the underclothing, in reference to the presence of stains of blood or semen. The absence of blood-stains from the person and clothing of the accused is, however, quite compatible with the commission of rape, even upon a virgin.

Charges of criminal assault are sometimes brought against medical men and dentists, the woman alleging that the offence was committed when she was under the influence of an anæsthetic. The woman may honestly believe in the truth of the accusation, though it is entirely groundless.

This is due to subjective impressions excited by the anæsthetic, and the practical lesson is never to anæsthetise a woman except in the presence of a third person.

Signs of Virginity.—There is no one sign which is absolutely conclusive. The presence of an unruptured hymen, more especially if it is of full size, shows that vaginal penetration cannot have taken place, and is, therefore, presumptive proof that the woman is a *virgo intacta*. But the hymen may be destroyed by causes other than defloration—*e.g.*, by ulceration, surgical operations, etc.; or it may be congenitally absent. On the other hand, cases have occurred in which the hymen has had to be incised to allow parturition to be accomplished; in these instances it must, of course, have been naturally so incomplete as to permit coitus without rupture or laceration. It needs repeated intercourse to cause permanent dilatation of the vagina, and the rugose state of the vaginal mucous membrane is only removed by parturition.

Evidence that the woman has borne a child at some time or other may be found in a ruptured fourchette or perinæum; a dilated vagina, with loss of the rugæ from its mucous membrane; lacerations in the os uteri; areolæ round the nipples; lineæ albicantes, etc. Some of these signs, however, may result from causes other than parturition.

The question whether a woman is or is not pregnant, is sometimes of medico-legal moment. The presumptive evidences, such as cessation of the menses, enlargement of the breasts, etc., and the subjective sensations of the woman, are not reliable for legal purposes. The sounds of the fœtal

heart, and the movements of the fœtus, determined by a competent observer, are alone trustworthy.

Infanticide.—The killing of a recently-born infant, as by exposure or violence, is murder, and demands for its proof evidence of a similar nature to that necessary to substantiate any other murderous act. But the law presumes, until the contrary is proved, that every child is born dead; and hence it becomes necessary, in a charge of infanticide, for the prosecution to establish the fact that the child was alive at its birth, and had a separate existence apart from its mother. This, however, does not involve division of the umbilical cord or birth of the placenta. If the fact of live birth is not proved, and the mother has hidden away or concealed the dead body of the child, she may, in England, be punished for *concealment of birth.* In Scotland, if a woman conceal her pregnancy, and if it can be shown that she has been pregnant for at least seven months, and the child of which she was pregnant is dead or is amissing, she may be found guilty of *concealment of pregnancy*, it being regarded as the legal duty of every pregnant woman to make proper provision for the safe delivery of her child. In cases of this nature, the medical witness may have to undertake the examination of the woman with a view, for example, to determine whether she has been recently delivered of a child; or he may have to examine the dead body of the child, in order to determine if it was born alive, or what has been the cause of its death. No woman should be examined without her own consent, and, if she is under a criminal charge, without also being warned that the facts of the examination may possibly be used in

evidence against her. The practitioner should carefully remember that there are no circumstances, not even a judicial order, which justify him in examining a woman without her consent; it is well to have this consent in writing or expressed in the presence of a third person. Examination without consent makes the examiner liable to a charge of indecent assault, and also to an action for damages. Some of the questions arising in connection with the cases above alluded to will now be considered.

Has the Woman been Recently Delivered?—If the pregnancy has been a completed one, distinct signs may be expected (see below). But if abortion has occurred in the earlier months, there may be no conclusive evidence, unless the fœtus, or some part of the fœtal membranes, is discovered. In abortion at a later period, the signs will be similar to those met with at full time, but less pronounced.

Signs of Recent Delivery at Full Time:—

1. Woman pale, weak, with dark areolæ round eyes.

2. The breasts, especially from the second or third day onwards, are full; the superficial veins distinct; the nipples prominent, with pigmented areolæ as in advanced pregnancy; pressure causes colostrum or milk to exude.

3. Abdominal wall relaxed, and skin presents pink-coloured streaks, though, of course, any condition which has distended the abdomen may produce this result. A dark line may be traced from pubes to umbilicus, with a dark areola round the latter—appearances, however, which do not always accompany pregnancy, and may occur apart from pregnancy.

4. Uterus is to be felt through the abdominal wall as a firm, hard mass, generally lying to one or other side.

The actual size varies in different cases and with the date of examination.

5. Genitals swollen, contused, or lacerated, with clots of blood about them; os externum patulous; perhaps recent lacerations of cervix uteri or perinæum may be present.

6. Lochial discharge. This commences soon after delivery, when it is a sero-sanguineous fluid, with a characteristic odour; it soon becomes brownish, and afterwards, a yellowish-green. It may cease in the course of a few days, or continue for a fortnight or so.

Unquestionable evidence can only be expected if the examination is made at an early date. The above signs, for the most part, disappear in about eight or ten days, and sometimes even earlier.

The history in many cases of recent delivery, the subject of medico-legal investigation, is often very misleading. A woman, who desires to do so, often succeeds in concealing the fact that she is pregnant from those around her, and frequently, too, manages to get herself delivered of her child without attracting attention. There are numbers of instances in which a woman has been delivered of a child at full term and has almost immediately continued her occupation without exciting comment.

Signs of Recent Delivery in the Dead Body.—Proof of this is sometimes required in cases of criminal abortion. If the pregnancy has been an advanced one, and death occurs (as is usually the case) within a day or two after delivery, conclusive evidence may be secured; but if the woman survives the abortion for a few weeks, no certain signs will be found. The signs of early abortion disappear in the course of a few days. In addition to the external evi-

dences, as described in a living woman, the signs of recent delivery in a case of fatal abortion near full time will be:—

1. The uterus is like a large flat pouch, from nine to twelve inches in length; os uteri is wide open; cavity of uterus contains clots of blood or sanguineous fluid; inner surface has on it more or less decidua, and, where the placenta was attached, is darker in colour, has a raw appearance, and presents a number of semilunar or valvular openings.

2. The Fallopian tubes, ovaries, etc., are congested, and a *corpus luteum* of pregnancy may be detected. It must be remembered that whilst the last may be valuable confirmatory evidence, a similar appearance may result from pelvic conditions other than pregnancy.

When criminal abortion has been procured by mechanical means, there may be evidences of violence to the uterus (in the form of punctures or lacerations in the vagina or cervix), or to the body of the child. In law, the term *abortion* applies to the expulsion of the contents of the pregnant uterus at *any* time before the full period of pregnancy.

Had the Child reached such a point in development that it might, under favourable circumstances, have lived?—In order to establish a charge of concealment of pregnancy it must be proved that the pregnancy has endured for at least seven months, as it is concluded (though not with perfect accuracy) that a child born at an earlier date could not, under any circumstances, have lived. This proof must be obtained from an examination of the body of the child. The later stages of development are as follows:—

Fœtus at Sixth Month.—Length, nine to twelve inches; weight, one to two pounds; eyelids not adherent; pupils closed by pupillary membranes.

Fœtus at Seventh Month.—Length, thirteen to fourteen inches; weight, three to four pounds; eyelids not adherent; pupillary membranes disappearing; nails imperfectly developed; testicles in abdomen; centre of ossification in the first piece of body of sternum.

Fœtus at Eighth Month.—Length, fourteen to sixteen inches; weight, four to five pounds; pupillary membranes absent; nails reaching to ends of fingers; testicles in inguinal canal; meconium in cæcum and colon; centre of ossification in the second piece of body of sternum.

Fœtus at Ninth Month.—Length, sixteen to twenty-one inches; weight, five to nine pounds (average seven and a half pounds); skin more pale, plump, and tense than in the less mature; downy hair mostly disappeared from body; nails reaching to ends of fingers; head covered with fine hair; pupillary membranes absent; navel at middle point of body length (of doubtful value); testicles in scrotum, or labia majora closing in clitoris and vagina; meconium in lower bowel; a well-developed point of ossification in the lower epiphysis of the femur. This point makes its first appearance at the thirty-sixth to the thirty-seventh week; at the thirty-seventh to the thirty-eighth week it is the size of the head of a house-fly; at the full period it is from one-fourth to one-third of an inch in diameter. (Taylor.) Centres of ossification are now present in the third piece of the body of the sternum, in the cuboid bone, and the first coccygeal vertebra. (Luff.)

The above must be regarded as average statements, and the decision must be taken, not on any one feature, but upon a review of the whole of the characters which the body of the child presents.

Was the Child Dead or Alive when Born?—A child is only born, in the legal sense, when the whole of its body has come into the world, and the most positive *post-mortem* evidence that it has been born alive is usually taken to be the condition of the lungs as giving evidence of respiration. But it is, of course, possible that a living child might be destroyed by violence (unavoidable, as pressure; or wilful) in its transit through the maternal passages; or it may live for some time after delivery without any, or with very feeble, respiratory efforts, and then be murdered; or, again, it may be born under circumstances that render respiration impossible—*e.g.*, it may be suffocated by the bed clothes, etc. It would be difficult, from an examination of the child's body, under these circumstances, to sustain a charge of infanticide, unless the violence, as, for example, puncture of the fontanelle, could manifestly not have been accidental; or unless the injuries have features which show conclusively their *ante-mortem* character. But, from these considerations, it is obvious that proof that the child has not breathed is not conclusive evidence that the child has *not* been born alive, or has *not* been done to death during or soon after delivery. On the other hand, a child may breathe before it has been completely born (in the legal sense of the term), and hence the occurrence of respiration is not absolute proof of legal live birth. There may, however, be positive proof that the child has died *in utero*—that is, that it has *not* been born alive; or clear proof of live birth may exist.

Evidences of Death *in utero*.—The child may be wholly immature, when it will reasonably be concluded that it was not born alive; or there may be evidences of Intra-Uterine Maceration. These are:—

1. Body generally, flaccid, so that it becomes flattened when laid on the table.

2. Skin dark red in colour, especially over trunk; cuticle separated or easily removed, and on hands and feet, blanched, corrugated, sometimes raised into vesicles; reddish serum in subcutaneous tissue.

3. Bones of head freely movable on one another, and soft parts generally easily detached from the bones.

These facts, together with the absence of the odour and greenish colour of the integument, distinguish intra-uterine maceration from putrefaction in air.

The above is what may be expected if a child is retained in the uterus for some eight or ten days after its death; when retained for a long time, the tissues may be largely changed into a saponaceous material, or the body become encrusted with phosphate of calcium. If a child has only been retained some twenty-four hours, it may be impossible to distinguish it from one that has died during delivery, or has died after delivery but without breathing.

Proofs of Live Birth.—Live birth, in the legal sense of the term, means complete delivery of the body of the child. Hence, as a child may breathe whilst yet in the maternal passages, and frequently does breathe as soon as its head is born, proof that the lungs have been expanded is not conclusive proof of *legal* live birth. But if the condition of the lungs shows that the respiratory act has been full and complete, and there is nothing to indicate that there has been unusual delay in delivery, the medical witness may express a strong opinion that the child has almost certainly been born alive, though he may be unable to swear positively it is impossible that the acts of respiration were

performed before complete delivery was accomplished. The evidences pointing to live birth will now be considered:—

1. Changes in the Respiratory Apparatus. Mere expansion of the chest is no proof that respiration has occurred, nor is the level of the diaphragm of much value; it is on the condition of the lungs that a decision must be founded.

Fœtal lungs.	Lungs After Full Respiration.
(1) Lungs unexpanded and confined to upper and back parts of chest.	(1) Lungs more or less completely filling the thorax, overlapping the heart, and pushing down the diaphragm.
(2) Margins sharp and well-defined.	(2) Margins rounded.
(3) Colour — chocolate-coloured or deep violet, and uniform all over.	(3) Expanded parts rose-red, and these, with limited areas not yet fully expanded and having a bluish colour, give to the lung a marbled or mottled appearance.
(4) Consistence — firm, dense, fleshy; microscope shows no expanded air-cells.	(4) Spongy, yielding, crepitant; expanded air-cells detected by microscope.
(5) When cut are found dense (no crepitation), yield but little blood, and this is not frothy; compressed under water no air-bubbles escape.	(5) When cut are spongy and crepitate, and frothy blood exudes; pressure under water causes the escape of air-bubbles.
(6) Sink in water.	(6) Float in water.

This last test—the *Hydrostatic Test*—is performed as follows:—The lungs, with the air-tubes and heart, are placed in distilled water at 60° F. Afterwards the lungs alone, each lung separately, portions of each lung, and portions of lung which have been violently compressed, are

successively treated in the same way. Fœtal lung tissue, under all these circumstances, sinks; whilst lungs which have been fully expanded by respiration, float. But a lung or part of a lung may sink in consequence of non-expansion (atelectasis) or of consolidation, and a child may live for several hours and yet the lungs have practically the fœtal character. All that can be said, therefore, when the lungs have this character, is that the lungs do not afford evidence that the child breathed; it is not possible on this evidence alone to say the child certainly did not breathe—at least to some extent. On the other hand, the lungs may be buoyant from causes other than respiration—viz., from putrefaction, and artificial inflation.

In *Putrefaction* the lungs are soft and sodden, have an offensive odour, contain gas (not in the air-cells) in bullæ of various sizes seen under the pleura, and gas is easily expelled, so that after compression the lungs sink. Evidences of putrefaction will, of course, be present in other organs, the lungs being comparatively late in undergoing putrefaction. When putrefactive changes in the lungs are decided, it is impossible to give a confident opinion as to whether respiration has occurred or not.

Artificial Inflation.—The lungs will float in water; but, when cut into pieces, some of these will sink, and those that float will sink after compression. To the last part of the statement, however, there are exceptions. And it must be remembered that, when respiratory expansion has only been partial and incomplete, compressed pieces of the lung may sink in water. The lungs, after artificial expansion, may have a reddish colour; but there is no marbled appearance, no frothy blood on section, and the efforts at inflation

may have also distended the stomach and intestine. Inflation of the lungs is only accomplished with difficulty. It may be produced by breathing forcibly into the child's mouth, or by introducing air through a catheter passed into the trachea. Thus it could scarcely be attempted except by a medical man, but in a charge of infanticide it might be suggested for the defence that the distention of the lungs was not due to natural respiration but to artificial inflation.

2. Changes in the Umbilical Cord. Absence of the cord, with the existence of a granulating surface, purulent secretion, or a cicatrix, would show that the child must have lived for several days, as the cord usually separates on the fifth, but never earlier than the third day. The presence of a red inflammatory line (capillary congestion) on the skin of the abdomen round the attachment of the cord, is also a proof of vital action. The cord, before separation, becomes flattened, dry, and shrivelled, the drying commencing at the free end; and, during separation, the umbilical vessels become gradually closed by concentric thickening of their coats. Shrivelling of the cord, but not separation of it, may occur in the body of a still-born child.

3. The presence of such substances as milk, sugar, starch, etc., in the stomach and intestine is very strong evidence of live birth. In the absence of attempts at artificial inflation of the lungs, and of the gases of putrefaction, the distention of the stomach, and still more of the stomach and duodenum, with air, so that these viscera float—when ligatured before removal—in water, is good evidence that the child has breathed, air being often swallowed during the early respiratory efforts.

4. The middle ear of a child at birth is filled with epithelial

cells, or embryonal connective tissue; in twenty-four hours or so it becomes distended with air.

5. Exfoliation of the cuticle is a sign of live birth, but it does not, as a rule, commence until the child has survived for a day or two. It may not be complete for two or three weeks.

6. The condition of the foramen ovale and of the vessels peculiar to the fœtal circulation is not absolute evidence either one way or the other, for these may be closed even during intra-uterine life, or may remain open long after birth.

7. The expulsion of meconium and of urine may occur before the child is born, and, therefore, does not prove live birth.

8. The existence of rigor mortis shows that a child has been recently living, but is no proof of live birth. (Taylor).

What was the Cause of the Death of the Child?—This must be determined on general principles. It must be remembered that a child may die in the course of delivery, as by compression of the head in protracted and difficult labour, pressure on the cord, etc.; or it may be accidentally killed after birth in consequence of the mouth and nostrils being obstructed by the bed-clothes or discharges; or again, hæmorrhage from the divided cord may lead to death. Hence, unless there is, in addition to distinct evidence of live birth, proof of violence wilfully applied, it is scarcely possible to sustain a charge of homicide. Even when the cause of death has manifestly been a violent one, the violence may have been accidental, as in precipitate labour. In such a case the umbilical cord will have been torn

through, not cut; fracture of the parietal bone or bones, extending into the frontal and temporal, may be present; but little or no other injury. Criminal violence is nearly always much in excess of that necessary to cause death, and evidences of it are usually found in several parts of the body. Marks of violence may be due to attempts to aid self-delivery. In doubtful cases, very careful examination for evidences of violence must be made, as in some cases—*e.g.*, throttling or suffocation—these may be but slight; but here again injuries wilfully inflicted are, as a rule, distinctly in excess of what is necessary to secure the death of the child. Suffocation, strangulation, and throttling, are frequent methods of infanticide, and are to be detected by the usual signs (see p. 45). A caput succedaneum must not be mistaken for the results of criminal violence. The integuments are swollen from effusion of serum, and perhaps also of blood, but there is no abrasion of the surface, or fracture of the bones. In very exceptional cases, however, fracture of the skull has resulted from prolonged and difficult labour. When a mark is found on the neck, it is sometimes suggested that it is due to strangulation by the umbilical cord. This, at most, produces a soft, slightly ecchymosed mark, without any abrasion. A parchment-like mark with abrasions and considerable injury to the deeper tissues cannot be due to the umbilical cord.

A medical witness may be asked to express an opinion upon the question whether the body of the child could be the child of the prisoner. To form such an opinion, the practitioner must endeavour to fix the date of the woman's delivery, and then decide whether the condition of the child's body is in harmony with birth at or about that date.

Examination of Blood Stains.—The stains may be found on clothing, weapons, furniture, etc. A careful note of the exact position, number, size, and shape, should be taken; and it may be well, in some cases, to photograph the stains or make a drawing to scale. If the stain is a recent one, a bright scarlet colour indicates arterial, and a dark purplish-red colour venous blood; but the latter, on exposure, soon becomes bright red. Any blood stain, too, in the course of a few days, becomes of a reddish brown colour (the hæmoglobin being changed to methæmoglobin or even to hæmatin) and may then remain unaltered for years; in this condition, therefore, it is impossible to say anything more definite concerning the age of a stain than that it is not recent. This change in colour may take place very early when the atmosphere contains various impurities, such as are common in the air of large manufacturing towns. The existence of spots, as from the spurting of an artery, would show not only arterial bleeding, but also that the wound had been inflicted during life. This, however, could only be expected from the wounding of a small artery, and at some little distance from the wound; a large artery, when cut, rapidly produces a pool of blood. The fact that the blood in a blood-stain is coagulated, is not absolute proof that it was effused during life, as blood shed soon after death will coagulate.

Proof that stains are or are not due to blood may be obtained by microscopical and chemical examination, and by spectrum analysis; mere physical appearances are often quite unreliable. Thus, for example, the marks of rust on knives, or the stains (citrate of iron) due to cutting acid fruits, often closely resemble old blood-stains. On the other hand,

a thin film of blood on the blade of a weapon has a yellow colour rather than the red appearance suggestive of blood.

Microscopical Evidence.

1. A blood stain gives to cloth, linen, etc., a degree of stiffness, and a low-power lens shows the stain to have a glossy appearance and a peculiar crimson-red colour, with each fibre invested by a coating of coagulated blood—a very characteristic appearance. In stains on dark cloth, no colour may be visible; the fibre, however, will be stiffened by coagulated albumen.

2. Detection of red blood corpuscles.—A portion of the clot from a stain on cloth or a scraping from a weapon, placed on a glass slide with a small quantity of water and then gently pressed with a cover-glass, will show the corpuscles; or the stain may be moistened with water and some of the fluid squeezed on to the slide. Too much water may swell up the corpuscles and destroy them. It must be remembered also that, more especially in old stains, the corpuscles may be shrivelled or otherwise altered in shape. As the corpuscles in all mammals (except the camel tribe) are circular and non-nucleated, it is impossible to distinguish human blood from that of other mammals. From the blood of birds, reptiles, and fishes, mammalian blood is easily distinguished, as in all these animals the corpuscles are oval and nucleated.

3. Detection of *hæmin* crystals.—Evaporate a solution of the stain or a piece of clot on a glass slide with glacial acetic acid and a little common salt to dryness. In the residue, small dark crystals *(Teichmann's crystals)*, usually in the form of rhombic plates, are detected by a high power of the microscope.

CHEMICAL EVIDENCE.—A solution of the hæmoglobin in distilled water must be obtained. A stained piece of cloth, linen, splinter of wood, etc., may be suspended in water in a test tube; large stains on weapons may be scraped, and the scrapings added to water; but in the case of a slight or doubtful stain the surface of the weapon should be brought into contact with a little water on a glass plate. In each case blood (hæmoglobin), if present, will communicate a red tinge to the fluid, which may be tested as follows:—

1. Add to one part of the fluid a weak solution of ammonia; the colour is merely slightly heightened. A strong solution of ammonia will give a brownish tint to the fluid.

2. Heat another portion of the fluid to about 170° F.; the colour is destroyed, and a dirty brownish coagulum formed. The coagulum is soluble in caustic potash, the solution being light green to transmitted, and red to reflected light.

3. Guaiacum Test.—Add to the fluid a few drops of tincture of guaiacum; a whitish precipitate of guaiacum resin falls, and this, on the addition of ozonic ether (which contains peroxide of hydrogen) dissolves, giving a sapphire-blue solution, either immediately, or in the course of a few seconds. This test may be applied to the stain itself. A piece of damp white blotting-paper is pressed on the moistened stain, and then successive applications of the guaiacum and ozonic ether are made to the stained paper, and the blue colour obtained. Or the reagents may be applied to the stained article of clothing when this is of a light colour, a method peculiarly valuable when attempts have been made to remove blood stains by washing, etc. Saliva, nasal mucus, potassium iodide, and other materials,

will give a more or less marked blue colour with this test. Hence the test is not quite conclusive of the presence of blood, but when yielded by a *red* stain, the presumption in favour of blood is very strong. Ferric salts and some other substances will give a blue colour with guaiacum alone.

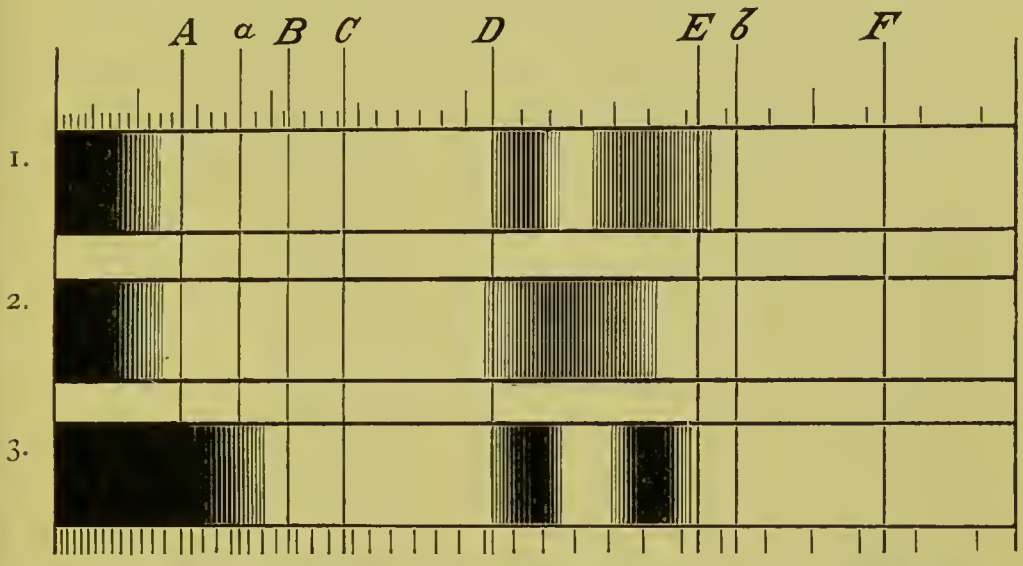
Note I.—Age or heat interferes with the solubility of hæmoglobin; hence stains or clots which are old, or which have been heated, will not respond to the first two tests. But a weak solution of ammonia, aided by heat, will in these cases dissolve the altered hæmoglobin, and the solution can be tested by the guaiacum test and by the spectroscope. Alkalies, as in soap, also rapidly change hæmoglobin into an insoluble form.

Note II.—The colouring principles of cochineal and of roots and woods, when treated with ammonia, become a deep crimson, whilst the red colours of flowers and fruits are changed to a blue or green; in none of these is the colour, as is the case with hæmoglobin, destroyed on boiling.

Note III.—*Iron-mould* spots are not soluble in water. A solution in hydrochloric acid gives a precipitate of Prussian blue with ferrocyanide of potassium; or the spot may be moistened with glacial acetic acid, and after a few minutes, with a solution of tannin, when it will become of a bluish purple colour. *Red-paint* spots are not soluble in water, but a solution in nitric acid will show the presence either of iron or lead.

Spectrum Analysis.—This is an extremely delicate method for the detection of blood, but it requires both care and experience. It has the great advantage of not interfering with the subsequent application of the chemical tests. A solution of recent blood gives two absorption bands—one

in the yellow area, and another in the green. After a time these two become replaced by a single broad band—the spectrum of reduced hæmoglobin. Very old stains give the spectrum of *hæmatin*, the number (one or two) and position of the absorption bands in which vary with the reaction of the solution. Blood containing carbonic-oxide-hæmoglobin



1. Spectrum of oxy-hæmoglobin. 2. Spectrum of reduced hæmoglobin.
3. Spectrum of carbonic-oxide-hæmoglobin.

also gives two absorption bands (see p. 47). A solution of alkanet root (used as a red dye) in alum, gives two bands similar to those due to oxy-hæmoglobin, but there is also an additional band situated in the green where this passes into the blue portion of the spectrum.

Note.—There are no tests by which the stains of menstrual blood can be distinguished from blood stains due to abortion, wounds, etc.

Recognition of Hair, Fibres, etc.—The recognition of these on weapons, or in blood-clot, may be important aids in securing conviction in cases of criminal violence. They should be examined microscopically, using a magnify-

ing power of about 300 diameters. Taylor's description is as follows:—

Cotton is seen as a flattened band, twisted so as to assume a more or less spiral form.

Linen fibre is of rectilinear form, with jointed markings at unequal distances, the fibre tapering to a point.

Silk has a regular cylindrical form, and there are no markings upon the surface. It has a strong refracting power on light, and this gives to the fibre a well-defined boundary.

Woollen Fibre (as in cloth, etc.) is irregular, contorted, of unequal thickness, and has irregular transverse markings—the margins of imbricated epithelial scales.

Hair (human) is seen as translucent cylinders, variously coloured, and with markings similar to those on wool; the markings are less conspicuous, and the hair is more uniform in width. A cortical and a medullary part can be distinguished.

Hairs from the lower animals are, for the most part, shorter, thicker, and less transparent than those of a human being.

Dying Declarations.—A person dying from the effects of injury or poison may express a desire to make a statement of the circumstances under which the injury was inflicted or the poison administered. If there is sufficient time, a magistrate or the procurator-fiscal should be summoned, and he will take down the statement in proper legal form. But if death appears to be imminent, the medical attendant may be called upon to receive the statement. In doing so, he must note whether *the injured person has the conviction or belief that death is impending*, as it is only a

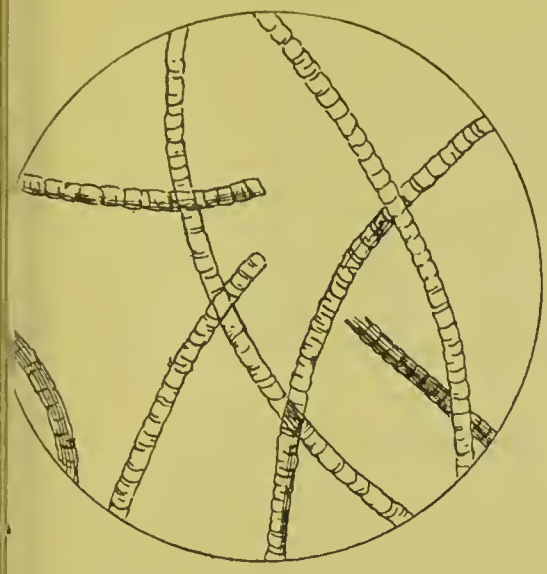


FIG. 1.—WOOLLEN FIBRES.
(Magnified 340 diameters.)

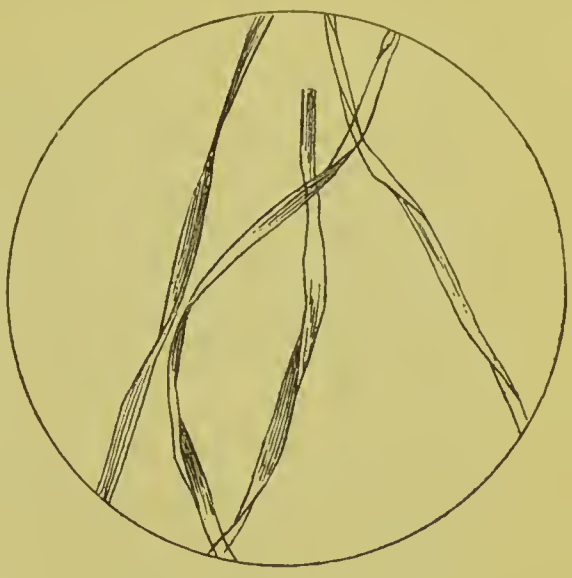


FIG. 2.—COTTON FIBRES.
(Magnified 340 diameters.)

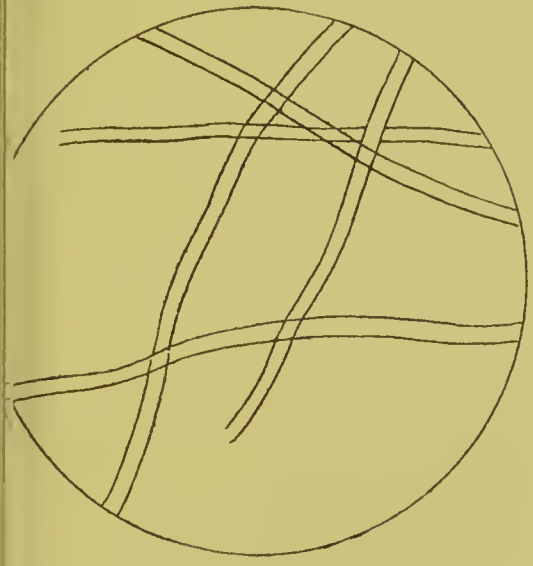


FIG. 3.—SILK FIBRES.
(Magnified 340 diameters.)

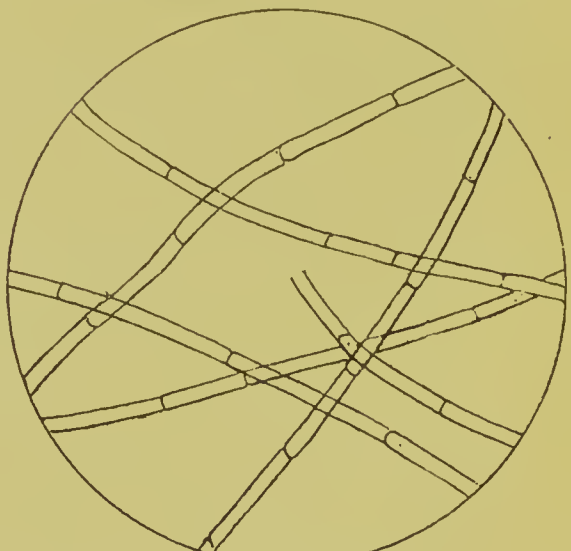


FIG. 4.—LINEN FIBRES.
(Magnified 340 diameters.)

From Dr. Luff's *Forensic Medicine and Toxicology*, by permission of Messrs. Longmans & Co.

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declaration made under the influence of this belief that will be admitted as evidence against any one charged with causing his death. Further, the statement must be expressed in the *exact words* uttered by the dying man; no leading questions must be put to him—the declaration must simply contain the information which he *voluntarily* offers.

Presumption of Survivorship.—When two or more persons who are related to one another are killed by a common cause, the heir to their property may vary according as one or other has survived longest. In some cases there may be fairly definite indications, such as one body being warm whilst another is cold, the presence of rigor mortis in one and its absence from another, etc. In other cases, there is only such a general presumption as arises from the comparative age and strength of the persons, with perhaps a knowledge of the degree of danger to which they were respectively exposed. It does not, however, lie with the medical witness to decide the question of survival; that decision rests with the judge and jury after hearing all the facts that can be proved. In the absence of evidence, the law presumes that the persons died at the same time. Any one claiming property therefore on the ground of survivorship must establish a reasonable presumption that such survivorship actually occurred. Thus, a man and his wife were drowned under unknown circumstances. The property was vested in the wife, and would, therefore, pass to her heirs, unless the next of kin of the husband could show that the husband survived his wife. In the case referred to this could not be done, and, consequently the wife's heirs succeeded to the property.

TOXICOLOGY.

Toxicology is the department of medical science concerned with the study of poisons—their properties, the effects they produce, their antidotes, and the tests by which they are detected and identified.

A poison, in the popular sense of the term, is a substance which, when taken *in small quantity*, is capable of producing harmful results. In legal medicine, however, the term has a wider significance. The administration of a large quantity of a substance, which in a small dose may be harmless, with intent to injure or kill, will render the administrator liable to the criminal law. The law does not define the term "poison," but leaves it to be decided by the evidence in each particular case whether the substance administered is, or is not, "a poison or other destructive or noxious thing." This decision will be largely determined by the medical evidence. And it must be remembered that a substance, which in certain doses, administered at suitable intervals, and in particular diseased conditions, will act as a valuable remedy, may in the same doses produce disastrous results if given with too great frequency, or in other and unsuitable pathological states. Hence the medical witness must be very careful how he answers the question, "What is a poison?"

A poison may be given to cause annoyance, to produce grievous bodily harm, or to cause death (homicide). The nature of the substance, and the quantity administered, or attempted to be administered, will be considerations likely to weigh with the jury in deciding the "intent" of the accused.

But it is a definite legal ruling that, in order to establish a criminal charge, there must not only be the administration of a "noxious" substance with guilty intent, but the amount given must be such as to be capable of proving "noxious." A medical witness may therefore be asked in any case whether, supposing a particular amount of some substance has been administered, that amount is or is not sufficient to injure or annoy the individual who has taken it.

Poisons may be introduced into the system by the various channels employed for the administration of medicines; they are eliminated through the various excretory glands. It is to be remembered that, of any poison which acts on the system by absorption into the blood, it is only that part which is actually circulating in the capillaries that produces poisonous effects. Certain poisons, *e.g.*, arsenic, lead, mercury, etc., may become deposited for a longer or shorter time in the viscera, more especially in the liver and spleen.

The effects of poisons vary with the nature of the poison, and the dose administered. They are influenced by idiosyncrasy, habit, disease, etc. Some poisons, *e.g.*, arsenic, opium, chloral hydrate, cocaine, etc., may be taken with safety in large doses when the individual has gradually accustomed himself to their use. *Tolerance* is said to be established.

Sources of Evidence in Cases of Poisoning:—

1. Symptoms.—These almost invariably manifest themselves very shortly after the poison has been taken—often, indeed, within a few minutes. There are none that are absolutely characteristic of poison as distinct from disease, but the sudden appearance in a healthy person of violent

symptoms, such as purging, vomiting, etc., for which there is no apparent explanation, should excite suspicion. If, however, no food, drink, etc., has been taken for several hours, poisoning is highly improbable. Should, on the other hand, such symptoms appear shortly after taking food or drink, and especially if several people who have partaken of the same food are attacked with similar symptoms, the suspicion of poisoning will be much strengthened. Apoplexy may, however, be mentioned as a natural cause of death, which not infrequently occurs immediately after taking food. Perforation of the stomach from extension of a gastric ulcer, too, usually occurs very shortly after food has been taken.

The rapidity with which symptoms of poisoning appear varies with the form in which the poison is administered, and with the condition of the stomach at the time of administration. If the poison is in solution and the stomach empty, absorption readily occurs, and therefore the onset of the symptoms is prompt. The opposite conditions postpone absorption, and the symptoms are therefore late to appear.

The repeated appearance of unexplained vomiting may be the only evidence of chronic poisoning, and a medical man in attendance upon a patient for such a condition needs to keep in mind the possibility that his patient is suffering from the effects of poison.

2. *Post-mortem* Appearances.—Some poisons produce death without leaving any appreciable change in the body. Even here, the negative conclusion that there were no evidences of death from natural causes, would be not unimportant. There are no *post-mortem* signs absolutely distinctive of poison. Similar changes may be produced

by disease. But in a particular case, it may be possible to offer a fairly confident opinion in favour of ordinary disease on the one hand, or poison on the other. Certain changes in the alimentary canal common to disease and irritant poisoning may be compared.

Redness.—Conspicuous redness, either uniform or in patches, of the gastric mucous membrane, and especially at the cardiac end of the stomach, is common in cases of irritant poisoning. The redness usually becomes brighter on exposure to the air. But a similar appearance may result from gastritis altogether apart from poisoning, and not infrequently accompanies death from heart disease. Hence, without other evidence, redness of the mucous membrane of the stomach is not a proof of death from poisoning.

Ulceration.—This is not a common result of poisoning. In ulceration due to disease there is redness of the mucous membrane limited to the edges of the ulcer, but irritant poisons (*e.g.*, arsenic) cause wide-spread redness. The ulcer due to disease has a clean, punched-out appearance, with smooth, thickened edges, whilst that resulting from an irritant poison is apt to be irregular in shape, and the edges are not conspicuously thickened. Arsenic, or other poison, may be found adhering to the ulcer. The history of symptoms will be very important. In simple gastric ulcer the symptoms may occasionally be concealed, but in no case of irritant poisoning has ulceration been found without well-marked symptoms of gastric irritation having previously existed.

Softening.—The wall of the stomach may be so soft as to give way on handling. This may be due to a corrosive poison (*e.g.*, strong alkalies), or to some change the result of

disease, or it may be a *post-mortem* phenomenon. If due to poison—and it is only corrosive poisons which can produce it—evidences of the corrosive action will be found also in the throat and œsophagus.

Perforation.—The perforation produced by idiopathic ulcer is small, and the edges of the ulcerated opening are smooth and thick. The perforation due to some strong corrosive, such as sulphuric acid, is a large ragged opening with friable edges. The contents of the stomach may be found in the abdominal cavity, and the poison detected by chemical tests.

3. Chemical Evidence.—The poison may be detected by chemical tests in food or other substances administered to the victim, in the vomit, contents of stomach or intestine, solid viscera, or urine. An endeavour to determine the quantity as well as the presence of the poison must be made. Detection of the poison in the urine or solid viscera is of special value, because this proves that the poison must have been absorbed, and therefore must have had an opportunity of exercising its injurious influence on the tissues of the body. If only present in the alimentary canal, it may be suggested that the victim died from some other cause, and before the poison was absorbed; or that the poison was placed in the stomach after death. To establish a charge of homicidal poisoning, it is not absolutely necessary that the poison be detected in the body or evacuations, but there must be a reasonable explanation of the failure to find it. Failure may be due to the volatile nature of the poison, to the absence of chemical tests for it, to its complete elimination before death occurred, or to decomposition so that it can no longer be recognised.

4. Physiological Evidence.—This is derived from experiments on animals (dogs and cats). Under identical circumstances, two similar animals receive, the one a dose of the poison suspected to have been administered, the other a dose of an extract obtained from the contents of the stomach or the viscera of the victim. The effects are noted and compared. This method can give no information as to the *quantity* of the poison administered. It may be useful in cases of poisoning by substances (*e.g.*, some of the vegetable alkaloids) for which no satisfactory chemical tests exist.

5. Moral or Circumstantial Evidence. — This is more a matter of ordinary than expert evidence. It involves the question of motive; the behaviour of the accused person in reference to the procuring of poison, to the nursing, feeding, etc., of the patient, to the obtaining of medical assistance, and to the suggestion of holding a *post-mortem* examination, etc.

Duties of a Medical Jurist in a case of death from suspected poisoning.—He must enquire about the symptoms—their character; the time of their appearance in relation to the taking of food, medicine, etc., and to the time of death; must note and retain for examination any food, medicines, vomit, fæces, urine, stains on clothing, floor, etc.—those intended for analysis should be placed in clean glass vessels, which must be sealed, labelled and dated, so that they may be identified with confidence. The state of the clothing and the position of the body must be observed —this latter point may be of importance in determining the presence or absence of convulsions during life.

In making a *post-mortem* examination every organ must

be examined. This is of importance, because it may be suggested, in defence of an accused person, that death was from natural causes, even though poison was present in the stomach. More positive results, however, may appear from a complete examination. Thus the presence of hardened fæces in the rectum shows the absence of purging; poison, *e.g.*, arsenic, has been introduced *per vaginam;* suspicious deaths have been explained by the discovery of a foreign body in the larynx.

The viscera must be removed for chemical analysis. Place a double ligature on the lower end of the œsophagus, and on the duodenum, and remove the stomach with its contents directly to a *clean* glass or earthenware jar; treat the intestines in the same way; into a third jar put the liver, kidneys, and other solid viscera with the urinary bladder. Close each jar with a cork or glass stopper, cover this with oil-skin or parchment secured by string round the neck of the jar, and seal the knot. Affix to each jar a label with a distinguishing mark, date, etc.; keep a duplicate of each label with particulars of contents of each jar; and take steps to secure that these jars are not tampered with before they are handed over to the authorised analyst. No preservative or other fluid should be placed in the jar.

If the body has been buried, it can only be exhumed under an official order. The same general directions must be followed. It is important that some friend or relative be present to identify the body in the presence of the medical witness. It is also recommended to take some of the soil from the neighbourhood of the coffin, as it may contain arsenic, but this can scarcely be necessary unless the coffin is broken. All notes must be taken at the time.

The actual chemical analysis is usually conducted by an expert. It should indicate the amount of the poison as well as its presence. A response must be obtained to *all* the recognised tests, or the witness must explain why no reaction was obtained. All characteristic sublimates, precipitates, and metallic deposits, should be preserved for production in court. A positive opinion as to the presence or absence of the poison should be given. Lastly, the analyst must be prepared to swear that all his apparatus, reagents, etc., were free from the poison for which he is testing. Hence he should commence by making a blank experiment, using all the reagents, and distilled water instead of the fluid suspected to contain the poison.

The position of a medical man in attendance upon a case which he *suspects* to be one of chronic poisoning is a very difficult one. Perhaps the best thing for him to do is, without mentioning his suspicions to any one, to get two trained nurses and give them instructions not to leave the patient day or night. If the practitioner is *satisfied* that wilful poisoning is being practised, it is his duty to inform the police, taking into his confidence some member of the family he can trust, if such there be.

TREATMENT IN CASES OF POISONING.—Presuming the poison has been swallowed, the indications are :—

1. To remove the poison from the alimentary canal.
2. To neutralise its activity.
3. To counteract its effects.

These indications may be met as follows :—

1. The stomach may be evacuated by emetics, or by the stomach-pump or tube. *Neither the stomach-pump nor emetics must be used in cases of corrosive poisons* on account of

the damage that may be inflicted on the œsophagus, stomach, etc. Purgatives are sometimes required to complete the removal of the poison. In using the stomach-pump, a pint or so of warm water is first pumped *into* the stomach, and then the same quantity of stomach contents withdrawn. This is repeated several times. Such procedure secures thorough washing out of the stomach, and also prevents injury of the wall of the stomach, which might well arise if the suction action of the pump were exerted when the stomach was empty.

2. Remedies used to neutralise the activity of poisons are antidotes. Some of these are *mechanical*, preventing absorption of the poison; animal charcoal is supposed to act in this way in poisoning by phosphorus. *Chemical* antidotes convert the poison either into an insoluble or an innocuous material; chloride of sodium in poisoning by silver nitrate, and magnesia in sulphuric acid poisoning are examples respectively. *Physiological* antidotes are of service after the poison has been absorbed; they *oppose* the physiological action of the poison. Thus atropine is given in poisoning by opium; strychnine in chloral poisoning.

3. It may be necessary to take steps to directly counteract certain dangerous effects of the poison in order to keep the patient alive until the antidotes have an opportunity of acting, or the elimination of the poison is secured. Artificial respiration in poisoning by hydrocyanic acid is an example of this necessity.

Classification of Poisons.—In speaking of classes of poisons the following terms are employed, viz.:—

Corrosive Poisons.—These destroy the tissues by direct chemical action. When swallowed, they produce *immediate*

and violent pain in the mouth, throat, stomach, etc. The mineral acids, the alkalies, corrosive sublimate, are examples.

Irritant Poisons.—These cause inflammation in the gastro-intestinal tract. The symptoms they produce—vomiting, purging, abdominal pain, etc.—do not as a rule appear for half-an-hour or more after the poison has been taken. Arsenic, cantharides, etc., are irritant poisons. Corrosive poisons if diluted may act as pure irritants.

Neurotic Poisons.—These, after absorption, act on the nervous system, producing such symptoms as convulsions, paralysis, coma, etc. Many of them depress the excitability of the central nervous system, and throw the patient into a state of coma. These are called *narcotic* poisons. Opium and alcohol may be mentioned as examples. Others, as strychnine, increase the excitability of the nerve centres. Some vegetable substances containing alkaloids that act on the nervous system, cause symptoms of irritation in the alimentary canal before the specific symptoms, due to the alkaloids, appear. These are therefore sometimes called *narcotico-irritant poisons.* Hemlock, aconite, and poisonous fungi are examples.

Some of the more frequently employed poisons will now be noted.

Sulphuric Acid : *Synonym, Oil of Vitriol.*—This is a typical corrosive poison. It is sometimes used for homicidal purposes in the case of children. Accidental and suicidal poisoning are more common. One drachm has proved fatal in an adult, 40 minims in a child one year old. Dilution, and the presence of food in the stomach, will lessen

the activity of the acid. Death may be rapid from shock, or perforation of the stomach; or secondary consequences—such as stricture of the œsophagus—may prove fatal at a later date. Those who recover are liable to irritability of the stomach and intestine.

Symptoms.—The symptoms are:—Immediate and excruciating pain in mouth, gullet, and stomach; speaking and swallowing difficult or impossible; vomiting of dark-coloured acid matter, which stains the clothing, sometimes also shreds of mucous membrane. Lips, neck, etc., show brown spots from spilling of acid on the skin. Mucous membrane of mouth and tongue white, or resembling soaked parchment, afterwards becoming grey or brown. (If the poison has been carried to the back of the throat in a spoon or phial, these appearances in the mouth will not be present.) Patient may be found writhing in agony, and soon manifests evidences of shock—*e.g.*, coldness of the surface, feeble pulse, etc. Cough, dyspnœa, lividity, may result from irritation of the larynx. If any acid has entered the larynx, there may be rapid swelling of the mucous membrane and urgent symptoms of suffocation.

Treatment.—1. Neutralise the acid by magnesia (one or two tablespoonfuls in water) or alkaline carbonates, as baking or washing soda. Chalk, plaster from ceiling or wall, soap and water, are often at hand. 2. Give soothing and demulcent drinks—*e.g.*, oil or milk. 3. Stimulants *per rectum* may be needed for the shock, and morphine hypodermically to relieve pain. N.B.—Neither the stomach-pump nor emetics must be used on account of the disorganisation of the pharynx, gullet, and stomach.

Post-mortem appearances.—Brown marks about face and

neck, with reddish stains on clothing; mouth, gullet, sometimes larynx, eroded, whitish or brown; stomach may be perforated by a large ragged opening with friable edges, or collapsed and contracted; the contents may be charred and strongly acid, the mucous membrane blackened on the summits of the folds, whilst between the folds it is red and inflamed, the vessels on the surface of the organ prominent and filled with black clots. These appearances will vary with the concentration of the acid, and with the length of time the patient survives. The longer the period before death, the more likely are evidences of irritation to be found in the intestine.

Tests for strong sulphuric acid—

1. Is, when pure, a colourless, oily liquid, intensely acid, and of high specific gravity—about 1·8.

2. Chars organic matter. A piece of wood or paper in contact with the acid rapidly becomes blackened.

3. Mixed with an equal quantity of water, heat is evolved.

4. Heated with copper filings, SO_2 is evolved. This gas is known by its odour, and by the fact that it first turns blue, and then bleaches, starched paper which has been dipped in iodic acid—that is, it decomposes iodic acid with liberation of free iodine.

Tests for dilute acid—

1. The dilute acid does not char organic matter until a considerable proportion of the water is removed. But if a piece of white paper be dipped in the dilute acid and then heated over a spirit lamp, as the water evaporates the paper will become charred. The same effect is produced when the dilute acid is heated in an evaporating basin with a solution of sugar.

2. Boil in a test tube with a small quantity of *veratrine;* pour on to a white plate and evaporate with a gentle heat—a dark crimson stain is produced (Wormley's test).

3. $BaCl_2$ gives a white precipitate ($BaSO_4$) insoluble in HNO_3. Collect the precipitate and heat it with ferrocyanide of potassium or charcoal to reduce it to BaS. Treat this with HCl; H_2S is given off, known by its odour and by blackening (PbS) white paper dipped in solution of lead acetate. This test detects the smallest quantity of sulphuric acid, free or combined.

Tests for acid when mixed with organic matter—food, vomit, contents of stomach. Fluids should be filtered, and the $BaCl_2$ test applied; more solid mixtures must be boiled with water, and a little acetic acid added to clear the fluid; then filter and try the barium test.

To test stains on clothes.—1. The stain, unless it has been washed, strongly reddens litmus. 2. Digest stained part in alcohol at a gentle heat, and filter; dilute the filtrate with water, and apply the barium test. The alcohol will dissolve out the free acid, but not sulphates, which are sometimes present in cloth. A control experiment should be conducted with an unstained piece of the fabric. The acid has been detected on articles of clothing after many years.

Stains Produced by the Mineral Acids—

Sulphuric Acid.—(Synonym, Oil of Vitriol). On skin, brown. On cloth, brown with red edges, or red (dilute acid). The stain on cloth has a damp, greasy feel, due to the absorption of water from the atmosphere. If of some standing, there is complete destruction of the fibre of the cloth.

Nitric Acid.—(Synonym, Aqua Fortis). On skin, bright yellow due to formation of picric acid. On cloth, yellow to orange-red or brown.

Hydrochloric Acid.—(Synonyms, Spirit of Salt, Muriatic Acid). On skin, whitish. On cloth, bright red changing to reddish-brown.

NITRIC ACID AND HYDROCHLORIC ACID.—These also are powerful corrosive poisons. They give similar symptoms to those produced by sulphuric acid. But they do not produce brown stains on the skin (see above). Neither do they darken the mucous membranes and stomach contents to the same extent. The tint produced by nitric acid on the gastric and other mucous membranes is yellowish; that due to hydrochloric acid is whitish or green. The fumes which arise from these acids, and especially from hydrochloric acid, account for the frequency with which the respiratory passages are involved, the vapours being drawn into the larynx during inspiration. Death has followed inhalation of the fumes of nitric acid. Congestion of the bronchial mucous membrane, and pneumonia have resulted. The treatment in each case is similar to that recommended in poisoning by sulphuric acid. The smallest fatal dose of nitric acid is two fluid drachms, and of hydrochloric acid one fluid drachm. To detect the poison in the contents of the stomach, these should be diluted with water, and then, after filtration, tests applied to the filtrate.

Nitric Acid.—The filtrate is acid. Neutralise with KOH and evaporate to get crystals of potassium nitrate. Dissolve some of these in water, and add a crystal or two of ferrous sulphate; now pour strong sulphuric acid down the side of the tube; the appearance of a reddish-purple or dark colora-

tion at the line of junction of the fluids proves the presence of nitric acid. Another test is to take some of the crystals of potassium nitrate, and add a few drops of strong sulphuric acid, and a crystal of brucine, when a blood-red colour appears.

Hydrochloric Acid.—The filtrate is acid. Silver nitrate gives a curdy white precipitate (AgCl) insoluble in nitric acid, soluble in ammonia.

Oxalic Acid.—The strongly acid taste prevents this being used for homicidal purposes. As it is largely used for domestic cleaning, it can easily be obtained and so is frequently taken with suicidal intent. It is also taken accidentally, being mistaken for Epsom salts. Sixty grains have killed a boy of 16, three drachms an adult. When the dose exceeds half an ounce—about three teaspoonfuls—death is probable, and usually takes place within an hour. In large doses and in concentrated solution the acid exercises an irritant, even a corrosive action, on the alimentary canal; but besides this it is a cardiac depressant and affects the nervous centres, sometimes producing convulsions, sometimes stupor and coma. If freely diluted, these remote effects may be the principal or only evidences of poisoning by oxalic acid.

Symptoms.—Hot acid taste in mouth; sense of constriction in throat; burning pain in stomach; vomiting of dark acid matter (mucus and blood); signs of collapse—cyanosis, cold sweats, small and rapid pulse.

If patient survives for a time, he is likely to be troubled with dysphagia, diarrhœa, etc.; oxalates may be found in the urine.

Treatment.—1. If vomiting has not occurred give apomorphine hypodermically—the use of the stomach-pump is risky.

2. Chalk (plaster), or whiting used for cleaning silver plate, magnesia are antidotes—they form insoluble salts. Note that the alkalies (potash, soda, and their carbonates) do not form *insoluble* oxalates. Hence, whilst they neutralise the acid, the resulting oxalates become absorbed and produce remote poisonous effects. They are not therefore antidotes for oxalic acid. Large quantities of water must be avoided, as this promotes the absorption of the poison.

3. Counteract the tendency to collapse by warmth and stimulants—giving brandy *per rectum*, or ether hypodermically.

Post-mortem appearances.—The mucous membranes of mouth, pharynx, and œsophagus are whitened and corrugated, contents of stomach brownish, the mucous membrane pale and softened. Exact appearances vary with degree of dilution of poison; the stronger the solution taken, the more marked are the evidences of irritation or possibly of corrosion. If the case has been prolonged, evidences of inflammation may be expected in the intestine. *Note.*—Oxalic acid cannot be detected in the blood, as it undergoes chemical change after absorption.

Tests for oxalic acid.—The acid occurs in six-sided prisms, has a sour taste, and does not deliquesce or effloresce on exposure. Heated, the crystals melt and are entirely dissipated, leaving little or no residue. Oxalic acid is soluble in water (about 1 in 11) and in alcohol.

Tests for acid in solution—

1. Solution of $CaSO_4$ gives on stirring a white precipitate

(calcium oxalate), soluble in hydrochloric acid, insoluble in acetic acid.

2. $AgNO_3$; white precipitate, soluble in HNO_3. Dry the precipitate and heat on platinum foil, when it is entirely dissipated with slight detonation. (Taylor.)

3. Lead acetate gives a white precipitate of lead oxalate which is soluble in HNO_3.

To test for acid in contents of stomach.

A. No antidote given. Macerate in distilled water, filter, neutralise filtrate with K_2CO_3; a solution of potassium oxalate is obtained.

B. Antidote (chalk) given. The acid is now for the most part present in the solid portion of the stomach contents, being precipitated as insoluble calcium oxalate. Allow then the mixture to settle, and decant the fluid; to the sediment add one-twentieth of its weight of K_2CO_3, and a small quantity of distilled water, and boil. The calcium oxalate is converted into soluble potassium oxalate. Now remove the insoluble matter by a filter.

In each case a solution of potassium oxalate has been obtained. To this add solution of lead acetate as long as a precipitate is formed. The precipitate is lead oxalate (with organic matter). Suspend the precipitate in water, and pass in H_2S. PbS is precipitated, oxalic acid remaining in solution. Filter, and boil the filtrate to expel excess of H_2S. The tests for the acid in solution may be applied to the fluid, or this may be evaporated and the crystals obtained.

Note I.—Oxalic acid is sometimes mistaken for sulphate of magnesium (Epsom salts), though the crystalline forms are not identical. Magnesium sulphate is bitter, not acid to the taste, and on heating loses water of crystallization but

leaves a distinct residue—the anhydrous salt. Oxalic acid is entirely dissipated by heat. Further, magnesium sulphate does not respond to the chemical tests given above.

Note II.—The mineral acids and oxalic acid may also be separated from organic mixtures by *dialysis*.

Salt of Sorrel or Salts of Lemon is a combination of oxalic acid with acid potassium oxalate. It is almost as poisonous as oxalic acid and produces similar symptoms. It is used commonly to remove stains from linen. It responds to the tests for oxalic acid, but on heating leaves a distinct residue of potassium carbonate.

Rhubarb and other plants contain oxalates. A pound of rhubarb contains oxalates equal to about 24 grains of oxalic acid.

Carbolic Acid (Phenol).—Poisoning by carbolic acid is usually either accidental or suicidal. The strong odour of the acid prevents it being used for homicide. The fatal dose is unknown ; 80 grains have killed an adult. Death may occur in the course of a few minutes, but is more common after the lapse of several hours. The local action of carbolic acid is at first corrosive and irritant, subsequently it acts as an anæsthetic ; when absorbed it has a paralysing effect on the brain and spinal cord and on the cardiac and respiratory activities.

Symptoms.—Hot burning sensation from mouth to stomach; mouth whitened; odour in breath; sometimes, but by no means always, vomiting, the anæsthetic influence of the poison on the gastric mucous membrane tending to prevent this symptom ; depressed circulation and collapse; stertorous breathing; evidences of action on nerve centres, *e.g.*, pupils

contracted and insensitive to light, stupor, coma, convulsions; urine dark olive-green.

Treatment.—Empty the stomach, and then wash it out repeatedly with a solution of sodium sulphate (or magnesium sulphate), which converts the acid into harmless sulphocarbolic acid. Demulcent drinks may be given freely. Warmth to the surface, and stimulants will also be needed, and possibly artificial respiration. In using the stomach-pump great care must be exercised on account of the injury inflicted on the œsophagus, etc., by the acid, and it may be well to use a stomach-siphon with a flexible tube instead of the stomach-pump.

Post-mortem appearances.—White marks on the skin about the mouth; mucous membranes of buccal cavity and œsophagus white and corrugated, the superficial layers perhaps converted into a thin slough; gastric mucous membrane whitened or brownish, sometimes softened, sometimes hardened and horny; lungs congested, and bronchial tubes containing brownish-red mucus, the poison being partly eliminated through the lungs.

Tests.—(1) odour; (2) only slightly soluble in water, freely in glycerine or ether; (3) gives a purple colour with a drop of a solution of ferric chloride. It does not redden blue litmus paper.

Carbolic acid may be extracted from the stomach contents, vomit, etc., by shaking with ether and decanting the clear fluid; then on evaporation of the ether, oily globules are left, which give the above reaction. From the urine it may be removed in the same way. Or the organic mixture may be distilled with sulphuric acid when the distillate will have the odour of phenol.

Poisoning by the Alkalies.—Potash, soda, and ammonia are corrosive poisons. They produce when swallowed, and more especially ammonia, a caustic or burning pain in the mouth, throat, and stomach, with signs of collapse. .

The *treatment* is the administration of demulcent drinks and some dilute acid. Vinegar is usually at hand. The use of the stomach-pump is negatived.

The *post-mortem* examination shows swelling and softening of the mucous membrane of the alimentary canal. In poisoning by ammonia, the inhalation of the volatile vapour is very likely to cause signs of inflammation in the respiratory passages. Even tracheotomy may be required, in consequence of obstruction of the glottis by the swollen mucous membrane of the larynx.

Tests.—A solution of potash is alkaline, and gives a violet colour with the flame test; acidified with hydrochloric acid it gives with platinic chloride a yellow crystalline precipitate—the double chloride of potassium and platinum.

A solution of soda is alkaline, and gives an intense yellow colour with the flame test.

Solution of ammonia is distinguished by its alkaline reaction and by its odour; it gives white fumes when a glass rod dipped in hydrochloric acid is held over it, ammonium chloride being formed.

Phosphorus.—In this country phosphorus poisoning occurs from the use—generally suicidal or accidental—of rat-paste (which contains 2 to 4 per cent. of the poison mixed with fat and flour, and coloured with some blue pigment), and of the heads of matches. Chronic poisoning, leading to caries or necrosis of the jaw, is sometimes produced among those who work with phosphorus; the

necrosis usually commences at the site of a carious tooth through which the fumes of the phosphorus reach and irritate the dental periosteum.

One and a half grains may be considered a fatal dose, though smaller quantities have produced death. Death may occur in from a few hours to several days—five or six days is a common date. The red or allotropic variety of phosphorus (obtained by heating yellow phosphorus out of contact with air) is inert.

Symptoms.—The most common course of the symptoms is the manifestation—generally after some hours—of *gastro-intestinal irritation*—garlic-like taste in mouth and odour in breath (which may in the dark appear luminous); intense thirst; pain and tenderness in throat and stomach; vomiting of mucus or bile (sometimes blood); colic, and sometimes diarrhœa. After some hours these symptoms cease, and the patient may recover, but frequently after a few days' interval, vomiting returns; diarrhœa, with blood in the stools, comes on; jaundice appears; there is enlargement of the liver and distention of the abdomen; and the patient becomes comatose, and dies in about five or six days after taking the poison. There are other cases in which the symptoms are mainly referred to the *nervous system*—painful cramps, somnolence, faintings, perhaps acute delirium. More rarely still the symptoms are *hæmorrhagic* in character—there may be more or less gastro-intestinal irritation at first, but soon hæmorrhages from various mucous membranes, and below the skin, appear. These, with jaundice, may last for some time, and the patient die from anæmia and cardiac failure. The groups of symptoms just described may be associated to a greater or less extent in one and the same case.

Treatment.—Emetics or the stomach-pump, to thoroughly wash out the stomach; then give milk with magnesia or animal charcoal. Old oil of turpentine is an antidote—it is said to oxidise the phosphorus into harmless acids. Oxygenated water (H_2O_2) acts similarly.

N.B.—Fixed oils must not be given, as by dissolving the phosphorus they would promote its absorption.

Post-mortem appearances.—These vary as the phosphorus has been taken in the solid form or in solution.

If *solid* phosphorus has been swallowed, small pieces may be found adhering to the mucous membrane of the stomach. These may be picked off, dried by bibulous paper, and reserved under water for future examination. The garlic-like odour and luminosity in the dark distinguish the pieces of phosphorus. Match ends and colouring matter should also be searched for.

Phosphorus *in solution* will give a garlic-like odour to the contents of the stomach, but there will be little or no evidence of inflammation in the alimentary canal.

The following may be found as evidences of the absorption of phosphorus: hæmorrhagic spots in the tissues and organs generally; blood-corpuscles disorganised; bloody serum in the serous spaces and cellular tissue; fatty degeneration of the liver, heart, kidneys, etc., and perhaps also in the muscles.

Note.—Fatty degeneration also occurs in poisoning by arsenic, antimony, and alcohol, but is not so rapid or so extreme as in phosphorus poisoning.

The symptoms and *post-mortem* appearances in phosphorus poisoning are not unlike those of acute yellow atrophy of the liver, and leucin and tyrosin have been found in the urine in each condition. The severe

degree of gastric irritation and the late appearance of jaundice in phosphorus poisoning are aids in drawing the distinction. In phosphorus poisoning, too, the liver is generally enlarged, whereas in acute yellow atrophy it is diminished in size; but even this distinction does not always hold good, for if the patient survive the administration of the phosphorus for some time, the liver may gradually lessen in size, and in some cases the early stage of acute yellow atrophy is accompanied by hepatic enlargement.

Chemical Examination of vomit or contents of stomach:—

1. Garlic-like odour; shake in a dark room to detect luminosity; if small pieces are seen, pick these out, wash, dry with blotting-paper, and seal up in a glass tube; minute particles can be run together by placing them in boiling water.

2. Treat with carbon bisulphide, which dissolves out the phosphorus; filter, and allow the filtrate to evaporate. The phosphorus is left behind in small globules, which ignite when touched with a hot wire.

3. Put in a flask with water, acidulate with sulphuric acid (to neutralise any ammonia resulting from putrefaction), apply heat, and conduct the vapour down a long condensing tube. This must be done in a dark room, when, if the slightest trace of phosphorus is present, the vapour in the tube will have a luminous appearance.

Note I.—Phosphorus must be tested for very shortly after death, as it soon becomes oxidised into phosphoric and other acids (non-poisonous). These being normal constituents of the tissues and of food, their presence in the body would be of no significance in a case of suspected poisoning by phosphorus. If the patient has survived

several days, it is not likely that free phosphorus will be found in the contents of the stomach or in the viscera.

Note II.—Phosphorus is excreted in the urine as hypophosphoric acid. To detect it, add nitric acid to concentrated urine and evaporate to dryness, when the residue bursts into flame. (Poulet.)

Arsenic: *Synonyms*, White Arsenic, Arsenious Acid. —This is a very important poison. It is employed with comparative frequency for homicidal purposes, as its almost complete freedom from taste allows it to be introduced into food without much chance of its being discovered. Poisoning has followed the application of arsenic, as an accidental constituent of dusting powder, to the skin; also, its employment in the form of an ointment to destroy pediculi on the scalp. Fatal results have been produced by arsenical pastes applied as caustics to cancerous tumours. It has even been introduced into the rectum and vagina for poisonous purposes.

The sale of arsenic is regulated by law. It can only be sold by a registered "chemist and druggist." An entry of the sale, together with the name of the purchaser, and the purpose for which the poison is required, must be made in a book kept for the purpose. Further, in less quantities than ten pounds, the arsenic must be mixed either with soot (1 oz. to the pound) or indigo ($\frac{1}{2}$ oz. to the pound). So discoloured, the poison is more likely to attract attention if introduced into food or drink. Various preparations known as "sheep-dip," used for destroying parasites in the wool of sheep, contain arsenic; others are employed for preserving skins, stuffed birds or other

animals, and bodies used for dissection; others for destroying weeds, etc. Arsenic is also contained in some "fly-papers," is used in enamelling some kinds of pottery, and is sometimes given to horses with a view to improve the appearance of their coats. Wall-papers are sometimes coloured green with Scheele's green (arsenite of copper); and other arsenical pigments have been employed to colour toys, sweetmeats, and various fabrics and articles of clothing. In the Pharmacopœia there are two 1 per cent. solutions, viz., *Liquor Arsenicalis* (Fowler's solution) and *Liquor Arsenici Hydrochloricus*. The former has a reddish colour and the odour of lavender, being coloured with the compound tincture of lavender.

Fatal Dose.—This has not been determined with great certainty. Some authorities give from 1 to $1\frac{1}{2}$ grains. Stevenson says from 2 to 3 grains "under circumstances favourable to the operation of the poison." A teaspoonful of arsenic is said to weigh 150 grains; a pinch, 17 grains (Husband). If the poison is in solution, or if the patient does not vomit, absorption is of course favoured, and therefore injurious effects are more likely to occur than under opposite conditions.

Symptoms.—These as a rule appear in from half-an-hour to an hour after the poison has been swallowed. But the time will vary with the form and dose of the poison. If given in solution or on an empty stomach symptoms will appear promptly. On the other hand, hours have been known to elapse before any symptoms appeared. In the majority of fatal cases death occurs in from eighteen hours to three days, the average being twenty-four hours. But each of these

extremes may be widely departed from. The commonest symptoms are—

1. Gastro-intestinal irritation—vomiting, the vomit being black (soot), blue (indigo), yellow (bile), or streaked with blood; epigastric pain; diarrhœa, often with tenesmus, and blood in the discharges.

2. Heat in the throat, with hoarse voice and great thirst.

3. Cramps in the calves of the legs.

4. Signs of collapse, fainting, small pulse, cold clammy skin, etc.

5. Restlessness, but, before death, stupor or convulsions may supervene.

In cases where a large dose (especially if in solution) is swallowed, and is not vomited, death may occur in the course of a few hours, the symptoms of irritation being slight, whilst those referred to the nervous system (collapse, convulsions, etc.) are prominent.

On the other hand, the patient may long survive the average period and yet die from the effects of the poison. In such cases the irritability of the alimentary canal persists, various skin eruptions may appear, muscular tremor or convulsions may follow, and death occur from coma or exhaustion.

When arsenic is given in repeated small doses for criminal purposes the gastro-intestinal disturbances will be less acute —there will be loss of appetite, occasional vomiting without obvious cause, diarrhœa, mental and bodily prostration, and in time, such physiological evidences of the poison as injection of the conjunctivæ, puffiness of the lower eyelids, tongue coated, with red tip and edges, and dryness of the throat. Sometimes arsenic produces a brown discoloration

of the skin. Herpes zoster and peripheral neuritis are other recognised results of arsenic. In many cases, however, there is little or nothing to distinguish chronic poisoning by arsenic from an ordinary gastritis. Vomiting frequently repeated after food, and especially after food prepared or administered by the same individual, should suggest to the medical attendant the possibility of poisoning—the examination of the urine may clear up the diagnosis.

Some individuals are extremely susceptible to the influence of arsenic, others by cultivation of the habit take large doses with apparent impunity.

TREATMENT.—The stomach should be emptied by means of emetics or the stomach-pump. The latter should be used to freely wash out the stomach. This is especially necessary when the poison has been given in the solid form, and on an empty stomach. If arsenic is given shortly after, or with food, it may itself act as an emetic; but on an empty stomach the poison irritates the mucous membrane, and causes the free secretion of mucus, which may "glue" the poison to the gastric wall. Hence the need for free washing. Copious draughts of water or milk, with white of egg, may be administered after the emetics. The best antidote is freshly precipitated ferric hydrate (made by adding solution of ammonia or washing soda in excess, to solution of ferric chloride), which forms with arsenic insoluble arseniate of iron. About three parts of the hydrate are required for each part of arsenic, but excess should always be given. It should be administered in the moist state, and, with regard to quantity, half an ounce will be on the safe side. It is to be noted that ferric hydrate is only an antidote for arsenic in solution. If solid arsenic has been taken,

reliance must be placed on emetics, and on washing out the stomach. Magnesia also may be given in such cases. It forms with arsenic a compound only slightly soluble, and, further, it neutralises the acid of the stomach, and so lessens the chance of the arsenic being dissolved. Stimulants may be needed, and morphine if pain is severe.

Post-mortem Appearances.—Nothing abnormal may be detected on dissection in cases in which a large quantity of the poison has been taken in solution, so that death has occurred at an early date from the remote effect of arsenic on the nervous system, and there has been little or no irritation of the stomach. In the great majority of cases, however, it is the stomach that offers evidence of the action of the poison. Arsenic, indeed, seems to have a specific effect on the gastric mucous membrane, for in cases in which the poison has been introduced through wounds or ulcerated surfaces, the mucous membrane of the stomach has been found inflamed, presumably therefore being an excreting surface through which the poison is eliminated. The appearances to be expected in the stomach are:—A layer of mucus, mixed with bile or blood, and with pasty-looking material containing arsenic, is found on the surface; red or brownish-red patches are seen, especially towards the cardiac end, and these become brighter on exposure to the air; hæmorrhages may be present in the mucous membrane, and there are sometimes erosions or ulcers to be seen.

The intestines, or at least the duodenum, may display inflammatory redness, and a similar condition has been observed in the rectum.

Arsenic may be found in the solid viscera, *e.g.*, the liver. It is not, however, a cumulative poison, being removed through the urine and other excretions. If the patient therefore survive for a time—two or three weeks, or even less—none of the poison may be found in the body. The usual experience is to find from half to two grains in the liver when death has occurred in from twenty-four to forty-eight hours. But even when the victim has only survived three or four hours, arsenic has been readily recognised in the liver and spleen.

The body as a rule putrefies slowly. Arsenic may often be detected long after death, especially in the pelvic bones and lower vertebræ. It is present as a sulphide due to the sulphuretted hydrogen of decomposition.

Tests for White Arsenic (As_2O_3)*—

I. *Physical Characters.*—White arsenic is found in two forms. It is seen, first, as a fine white powder recognised as crystalline (octahedra) when viewed through a lens. The other, and less common form, is known as the *vitreous* variety. It occurs in opaque, or translucent, often stratified, masses. The white arsenic of commerce is often this vitreous form reduced to powder. Added to water, the white powder does not become diffused through the fluid, but partly floats as a white scum on the surface, and partly collects into little masses or "islands." Cold water, allowed to stand for hours in contact with arsenic, only dissolves about half a grain to the ounce. The presence of organic matter (*e.g.*, tea, coffee, etc.) lessens the solubility of the

* It will save confusion for the student to speak of the metal as *arsenium* instead of metallic arsenic. The term *arsenic* should be reserved for arsenious oxide (As_2O_3).

poison. Water boiled with arsenic for an hour holds dissolved about twelve grains to the ounce. The vitreous variety is rather the more soluble of the two, and its solubility is increased by age.

II. *Sublimation Test.*—Heated in a glass tube it sublimes without melting, and gives a white sublimate of minute octahedral crystals. The vapour of white arsenic is free from odour, but arsenium when undergoing oxidation produces a garlic-like odour.

III. *Reduction Test.*—Mix with some reducing agent (ferrocyanide of potassium is one of the best), place in a dry, narrow, test tube, and slowly heat. The As_2O_3 is reduced to metallic arsenium (As), and this is deposited on a cool part of the tube as a metallic iron-grey ring. There may be a second ring higher up the tube and of a dark brownish colour. This is a mixture of As and As_2O_3, and at its upper part it fades into a white mist (As_2O_3), some of the metallic arsenium, as it has volatilised, being oxidised by the oxygen of the atmosphere. A garlic-like odour may be observed during the process, due to the oxidation of the arsenium. The fact that the metallic-looking sublimate is really arsenium, is established by the following considerations :—

(1) Its physical characters (see p. 118).

(2) Break off the part of the tube on which the deposit has been obtained, place it in a larger tube, and apply heat. The metallic ring is volatilised, and re-deposited on a cool part of the tube. At the same time, part of it is converted into As_2O_3 (as a crystalline sublimate), and if the heat is reapplied, the whole of it becomes so converted.

Note.—Whilst salts of mercury, antimony, cadmium, etc., will give metallic sublimates, when heated with a reducing agent, not one of these yields on heating a crystalline deposit. The production of this white crystalline sublimate under the influence of heat also excludes the possibility of the dark ring being carbon. It is necessary to note this, because sometimes the reducing agent employed is *black flux*,* which, of course, consists largely of carbon. And some of the carbon might be mechanically deposited on the tube, and thus, by a novice, come to be mistaken for arsenium.

(3) The metallic band is soluble in solution of chlorinated lime.

(4) NH_4HS, *on heating*, gives a yellow stain (As_2S_3), which is soluble in NH_4HO, insoluble in HCl.

The amount of arsenium in the metallic ring may be estimated by filing off the portion of the tube on which it is deposited, weighing, driving off the metal by heat, and again weighing.

IV. *Stannous Chloride Test.*—Heat stannous chloride with hydrochloric acid in a test tube; add a minute quantity of arsenic. The metal (arsenium) is deposited as a brownish precipitate. All the solid compounds of arsenium give this reaction, whilst the test applied to tartar emetic or other salt of antimony has a purely negative result.

Tests for As_2O_3 in Solution—

1. The aqueous solution is clear, colourless, free from odour, and almost free from taste. It has only a feebly acid reaction, but if, as the result of exposure, As_2O_5 has

* Black flux is made by heating tartrate of sodium in a closed tube; it is a mixture of carbon and sodium carbonate.

been formed, the acidity is more marked. On evaporation, octahedral crystals will be obtained.

2. H_2S in fluid acidulated with HCl gives a yellow precipitate (As_2S_3), soluble in NH_4HO, insoluble in strong HCl. Antimony gives an orange-coloured sulphide, soluble in strong HCl. The sulphide of cadmium is yellow and is insoluble either in HCl or NH_4HO.

3. Ammonio-sulphate of copper; a green precipitate of arsenite of copper (Scheele's green), soluble in NH_4HO and in HNO_3. Collect the precipitate, and test it by the reduction process.

4. Ammonio-nitrate of silver; a canary-yellow precipitate of arsenite of silver, soluble in NH_4HO, and in HNO_3. Try reduction test on precipitate.

5. Evaporate solution and obtain crystals of As_2O_3. Add a few drops of HNO_3 to convert this into As_2O_5. Dissolve this, neutralise excess of acid with NH_4HO, and add $AgNO_3$. A chocolate-coloured precipitate of arseniate of silver is produced.

MARSH'S TEST.—This depends upon the readiness with which arsenium unites with *nascent* hydrogen to form a gaseous compound arseniuretted hydrogen (AsH_3). Antimony forms an analogous compound (SbH_3). The properties of these two gases may be contrasted. To apply the test, generate nascent hydrogen, by the action of zinc upon dilute sulphuric acid, in a suitable apparatus. Then make a blank experiment (that is, add to the reagents in the apparatus a little distilled water instead of the suspected solution), this being especially necessary, as either zinc or the acid may be impure from the presence of arsenium. If the result of the blank experiment is negative, add

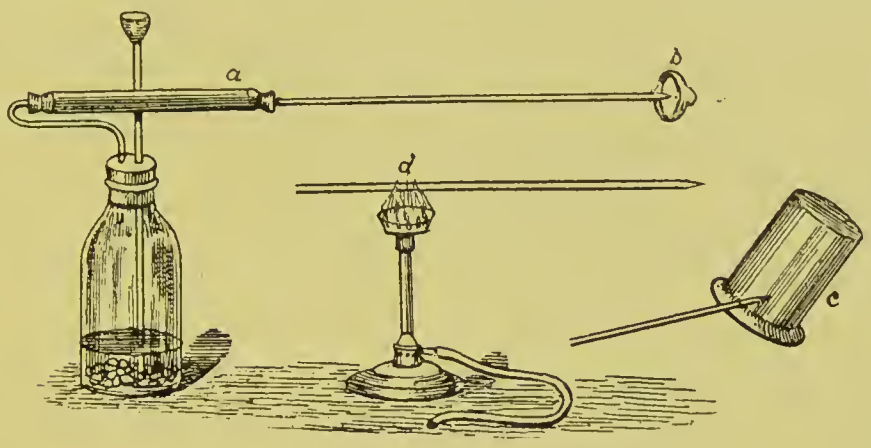
the suspected fluid (it is only for As_2O_3 *in solution* that Marsh's process is a test). AsH_3 (or SbH_3) is produced and is recognised by—

1. The properties of the ignited jet.
2. The results of the decomposition of the gas by heat.
3. The action of the gas on solution of silver nitrate.

1. *Ignited Jet (AsH_3)**—	1. *Ignited Jet (SbH_3)*—
(*a*) *Flame.*—Livid bluish-white; garlic odour; gives, on a cool surface, held *outside* the flame, a white crystalline sublimate (As_2O_3), soluble in water.	(*a*) *Flame.*—Greenish; no odour; white amorphous sublimate (Sb_2O_3), insoluble in water.
(*b*) *Deposit on porcelain.*—A piece of porcelain held in the *inner* part of the flame receives a black or steel-like deposit. This is bright and lustrous in the centre (As); outside this is a brownish ring, outside which, again, is white As_2O_3.	(*b*) *Deposit on porcelain.*—Less lustrous, sooty (Sb).
To prove the deposit is arsenium—	To prove the deposit is antimony—
Chlorinated lime dissolves it.	Chlorinated lime dissolves it only after long digestion.
NH_4HS only dissolves it slowly, and on heating; the solution leaves on evaporation a lemon-yellow stain (As_2S_3), soluble in NH_4HO, insoluble in HCl.	NH_4HS dissolves it rapidly, and the solution on evaporation leaves an orange stain (Sb_2S_3) insoluble in NH_4HO, soluble in strong HCl.
HNO_3, on heating, converts it into a white residue (As_2O_5), which, when neutralised, gives with $AgNO_3$ a chocolate precipitate of Ag_3AsO_4.	HNO_3, on heating, gives a white residue, which is not affected by $AgNO_3$.

* AsH_3 is extremely poisonous, and the operator must be careful not to inhale the gas. It leads to destruction of the red blood corpuscles, and to suppression of urine.

2. *Decomposition of the Gas by Heat.*—Heat the delivery tube of the Marsh's apparatus as the gas passes through it. The gas is decomposed, and arsenium or antimony, as the case may be, is deposited on the cool portion of the tube. To the metallic deposit all the tests used for distinguishing



THE HYDROGEN TEST FOR ARSENIUM.*

a, Apparatus for Marsh's test, with tube containing calcium chloride for drying the gas. *b*, Porcelain to receive the deposit of arsenium. *c*, Beaker held outside the flame to collect sublimate of white arsenic. *d*, Arrangement for heating delivery tube as gas is passing through.

the deposit on the cold porcelain (as above) may be applied. The following points also distinguish the deposits :—

(*a*) The As deposit is on the distal side of the spot to which heat is applied.

(*b*) Heat the deposit; it moves along the tube, and, by repeating the process, can be converted into a crystalline sublimate (As_2O_3), soluble in water. At the same time a garlic-like odour is produced.

(*a*) The Sb deposit is on the proximal side of the flame, or on both sides, as SbH_3 is decomposed at a lower temperature than AsH_3, and antimony is less volatile than arsenium.

(*b*) Heat the deposit; it moves along the tube, and is gradually converted into a white amorphous sublimate (Sb_2O_3), insoluble in water. There is no odour produced.

* From Professor Attfield's "Chemistry," by permission of the Author and Messrs. Gurney & Jackson, Publishers.

3. *Action of the Gas on Solution of* $AgNO_3$—

Pass the gas issuing from the delivery tube into a solution of silver nitrate.

AsH_3 precipitates the Ag in a fine state of division (black). Filter; the filtrate contains As_2O_3, as is shown on testing. The test may be applied by allowing the gas to come into contact with a piece of bibulous paper dipped in solution of silver nitrate. The paper is blackened by the reduction of the salt to metallic silver.

SbH_3 decomposes the $AgNO_3$, but all the Sb combines with the Ag as $SbAg_3$, which appears as a black precipitate. Hence, on filtering, the filtrate contains no Sb.

Observe that in each case a black precipitate is obtained. If the gas has been AsH_3, the filtrate gives the tests for As_2O_3; if SbH_3, testing the filtrate only gives negative results.

This method may be employed to separate a mixture of arsenium and antimony.

REINSCH'S TEST.—Boil the suspected solution with one-sixth of its volume of pure HCl, and add some strips of bright metallic copper (the HCl and Cu must be previously proved to be free from arsenium). If arsenium is present in the solution, an iron-grey deposit (an alloy of As and Cu) appears on the copper. Take the coated slip of copper, wash it successively in water, alcohol, and ether, dry, and gently heat in a dry test tube, when a sublimate (crystalline) of As_2O_3 will be obtained; dissolve this, and test the solution. Note that a number of metals (As, Sb, Hg, Ag, Bi) yield deposits with Reinsch's test, but in the case of three only is a sublimate obtained on heating the deposit, viz. :—

As gives a crystalline sublimate (As_2O_3), soluble in water.

Sb gives an amorphous sublimate (Sb_2O_3), insoluble in water.

Hg gives a sublimate of fine metallic globules.

To Test Organic Mixtures for As_2O_3—

In the vomit, or contents of the stomach, particles of As_2O_3 may be discovered. These should be picked out and examined by the above tests.

To a liquid, one-sixth part of its volume of HCl should be added, and Reinsch's test directly applied. Dialysis may also be employed to separate arsenic from organic liquids.

Solids should be boiled in water acidulated with HCl. The liquid so obtained may be tested by Marsh's and Reinsch's methods. The urine, similarly, may be concentrated, acidulated with HCl, and Marsh's and Reinsch's tests applied.

Another method is to take the solid substance supposed to contain arsenic, and after drying it, to finely divide it, and to distil with strong HCl, and collect the distillate. Fluids may be concentrated and treated in the same way, the chloride of arsenium being volatile.

Poisoning by Arsenical Wall-Papers (Scheele's green):—The symptoms are—Dryness and irritation of the throat, with dry cough; colicky pains, purging, vomiting; sleeplessness; a feverish state, and loss of flesh. These symptoms, having no obvious explanation and resisting treatment, should excite suspicion.

To Test Wall-Paper.—1. Place a strip of the paper in a solution of ammonia; a blue solution, due to a copper compound, is formed. Pour a little of this solution over some crystals of silver nitrate, yellow arsenite of silver is produced round the edges of the crystals. 2. Digest pieces of the

paper in hydrochloric acid, and apply Marsh's and Reinsch's tests to the filtered fluid. 3. Scrape the paper, and apply reduction, sublimation, and other tests to scraping.

Antimony.—Tartar emetic, or tartarated antimony ($KSbOC_4H_4O_6$), is the chief salt of medico-legal importance. The amount required to destroy life cannot be stated. Even as much as an ounce has been taken without a fatal result. On the other hand, a few grains have proved fatal. The extent to which vomiting and purging are excited will have an important determining effect. Death may occur within twenty-four hours, but is more common at a later period.

Liquor antimonii chloridi is a solution of chloride of antimony in hydrochloric acid. It is sometimes called *butter of antimony*, and is used in veterinary practice. Its dark colour is due to iron, which is present as an impurity. If swallowed, there will be evidences of the corrosive action of hydrochloric acid in addition to symptoms of poisoning by antimony. The *Vinum Antimoniale* of the British Pharmacopœia contains two grains of tartar emetic to the ounce.

Symptoms.—The following may be expected in cases of poisoning by tartar emetic: Metallic taste, thirst; sense of constriction in throat; heat in stomach. Nausea and vomiting are usually prominent symptoms; the vomiting continues after the stomach has been emptied, and the rejected matter may consist of white stringy mucus, sometimes tinged with blood (sometimes, however, large doses have failed to produce vomiting); cramps in belly, tenesmus and purging, with liquid stools. Besides these, there is

great prostration, shown by a rapid and feeble pulse, laboured breathing, etc. Sometimes convulsions occur.

Treatment.—If vomiting has not occurred, use the stomach-pump, or give apomorphine; encourage vomiting by draughts of greasy water. As an antidote, give tannic acid in water or a strong infusion of some vegetable astringent (*e.g.*, tea, oak-bark, cinchona, etc.). The resulting tannate is to some extent soluble in the acid of the stomach, and therefore must be removed by an emetic or the stomach-pump. When all the poison has been got rid of, irritability of the stomach may be allayed by opium or coffee. Stimulants and sedatives may be needed.

Post-mortem Appearances.—There is more or less inflammation of the mucous membrane from the throat to the duodenum. Aphthous-looking patches may be seen on the throat, and patches of softened mucous membrane found in the stomach; and the vessels of the brain and lungs are congested. In cases of chronic poisoning the liver has been found unduly soft, and easily broken down.

Tests for Tartar Emetic (as a solid)—

1. Is seen both as a fine white powder, and also in tetrahedral crystals; readily soluble in water (1 in 14 cold, 1 in 2 boiling).

2. Heated in the flame of a Bunsen burner, the salt is decomposed, burning with a violet flame, giving off the odour of burnt sugar, and leaving a black mass—a mixture of carbon and oxide of antimony, with some metallic globules (Sb).

3. NH_4HS. The salt treated with sulphydrate of ammonium becomes at once of a deep orange colour

No other metallic poison yields this result. As_2O_3 with NH_4HS becomes yellow, but only when heat is applied.

In Solution—

1. Colourless, faintly acid, metallic taste; yields, on evaporation, tetrahedral crystals.

2. H_2S gives orange precipitate (Sb_2S_3), insoluble in NH_4HO, soluble in strong HCl. The solution ($SbCl_3$) thrown into water gives a white precipitate of oxychloride of antimony. This was at one time known as *pulvis angelicus* or *powder of Algaroth.*

3. K_4FeCy_6 gives no precipitate. This distinguishes antimony from most other metallic poisons.

4. Galvanic test: acidulate with HCl, and place in a platinum capsule. Touch the platinum through the fluid with a piece of zinc. A black deposit (Sb) occurs at the point of contact. This black stain is dissolved by a few drops of HNO_3, and the solution, on evaporation, leaves a white residue—an oxide of antimony—which becomes of an orange colour when treated with NH_4HS. This test may be applied to fluids containing the poison mixed with organic matter.

5. HNO_3, dilute, gives a white precipitate, soluble in excess, and also in tartaric acid.

6. Marsh's test (see Arsenic).

7. Reinsch's test (see Arsenic). The antimony deposit is more dull and darker than the steel-grey arsenium deposit.

To detect Antimony in Organic Fluids—

Add a quantity of tartaric acid, boil for fifteen minutes and filter. Through the filtrate pass H_2S; an orange precipitate (Sb_2S_3) is produced. Dissolve this in strong HCl. Test one part by Marsh's method, another by

Reinsch's test, and throw a third part into water to get a white precipitate (SbOCl), which is soluble in tartaric acid. Or the galvanic test as described above may be employed.

In solid tissues, e.g., liver, etc.—Cut the tissue up small, and boil in water with HCl. Test the solution by Reinsch's method and other tests.

Mercury.—The chief strongly poisonous salt is the perchloride (corrosive sublimate). This is employed medicinally in doses of one-sixteenth to one-eighth of a grain. It is found either in heavy crystalline masses, or as a white crystalline powder. It is soluble in cold water (not very freely), more soluble in hot water, and still more soluble in alcohol and in ether. A child has been killed by a dose of 2 grains. Even in an adult, 3 to 5 grains would be a dangerous dose. Death is usually postponed for several days, though it has occurred in the course of half an hour. Subchloride of mercury (calomel) is a heavy white or cream-coloured powder. The medicinal dose is one-half to five grains. It becomes black (black-wash) when treated with lime water. *Red precipitate* is mercuric oxide; *white precipitate* is ammoniated mercury; *grey powder* is a mixture of metallic mercury with prepared chalk.

Symptoms.—These come on immediately, or in the course of a few minutes, after the poison has been taken. There is a coppery taste, a burning pain in the throat and gullet, with a sense of constriction on swallowing; pain in the belly, vomiting and purging, the discharges perhaps containing blood; diminution or suppression of urine (with possibly albuminuria), and signs of nervous and circulatory

depression. "The symptoms in the first instance resemble those of cholera; if the individual should survive several days, they are more like those of dysentery—violent straining and mucous discharges mixed with blood being very frequently observed" (Taylor). It may be noted that corrosive sublimate as a poison differs from arsenic (1) in having a well-marked taste, (2) in producing violent symptoms in a few minutes, (3) in more frequently causing blood in the evacuations.

Treatment.—Empty the stomach by means of emetics. The use of the stomach pump is inadvisable on account of the softened condition of the alimentary mucous membrane. Milk, raw white of egg, flour and water, are the best antidotes. They should be followed by an emetic, the resulting albuminate of mercury being to some extent soluble in the fluids of the stomach. Irritation of the stomach and intestine may be subdued by the use of demulcent drinks, and if necessary by opium.

Post-mortem Appearances.—The corrosive influence of the poison is seen in a softened, inflamed, condition and bluish-grey colour of the mucous membranes of the mouth, gullet, and stomach. The walls of the stomach may be so soft as to give way when the organ is being removed from the body. Signs of violent inflammation have sometimes been present in the cæcum, colon, and rectum; also in the kidneys. It will be observed that the presence of softening and inflammation in the mucous membranes of the mouth and gullet distinguishes the effect of this poison from the effect of arsenic.

Chronic Poisoning.—The symptoms are—Coppery taste; fœtid breath; swelling of gums, with loosening of the teeth;

salivation (this may occur in acute cases if the patient survive for a few days); diarrhœa; muscular tremors, etc.

Tests for $HgCl_2$ (Solid)—

1. Physical characters (see above).

2. Heat melts it, and on the cool part of the tube a sublimate of feathery crystals ($HgCl_2$) is seen. The salt does not, like As_2O_3, directly sublime; it first melts, and then rises in vapour.

3. Reduced by heating with K_4FeCy_6, metallic globules (Hg) appear on the cool part of the tube.

Tests for $HgCl_2$ (in Solution)—

1. H_2S: a yellowish precipitate, which rapidly becomes black.

2. KI: a yellow precipitate, which rapidly becomes scarlet, and is soluble in excess of KI.

3. KHO: a yellow precipitate of mercuric oxide.

4. $SnCl_2$: a white precipitate, changing to brown ("magpie test"), the mercuric chloride being reduced first to the mercurous state and then to metallic mercury.

5. Reinsch's test—a silvery-white deposit (Hg) on the copper occurs even in the cold, and at once on heating. The copper on which the deposit has been obtained, dried, and heated in a dry test tube, gives a sublimate of metallic globules (Hg).

6. Gold test: place a drop of the solution on a gold coin, acidify with HCl, touch the coin through the fluid with a piece of zinc or a steel key, a deposit of Hg will take place on the coin. The deposit may be dissolved in HNO_3, and the solution so obtained tested as above.

Tests for $HgCl_2$ in Organic Mixtures.—If present, evi-

dences of it will probably be found both in the solid and fluid portion of the stomach contents. The mixture should be heated with distilled water and filtered. The *filtrate*, after acidifying it with HCl, may be divided into two parts. Test one by Reinsch's method, and the other by H_2S, the precipitated HgS being subsequently reduced to get metallic globules (Hg). The *filter* should be boiled with water containing HCl for half-an-hour or so. Then filter, concentrate, and test as above. Any solid organic matter, *e.g.*, one of the viscera, may, after being finely divided, be treated in the same way.

Another method for detecting the salt, when mixed with organic material, either liquid or solid, is to shake up the suspected substance with twice its volume of ether. The ether is then decanted. On evaporation, crystals of mercuric chloride will remain, and may be dissolved and tested.

Lead.—Chronic poisoning among workers in lead (plumbers, painters, etc.) is not uncommon. Acute poisoning may result from the contamination of various articles of food and drink with lead, or from the administration of some salt of the metal. The commonest salt is the *acetate* (sugar of lead). This occurs in white (when impure, brownish-white) crystalline masses, something like broken loaf sugar. It has a vinegar-like odour, and a taste at first sweetish, and afterwards astringent. Soluble 1 in 4 of cold water, freely in boiling water. The fatal dose is uncertain. As much as an ounce has been taken without causing death. The other salts employed in medicine are: *Subacetate* (Goulard's extract), *iodide* (yellow scales), *nitrate* (colourless crystals), *oxide* (*massicot*, a yellowish-

brown powder; or *litharge*, bright, reddish-yellow scales). *White lead* is a mixture of carbonate and hydrate of lead; *red lead* is an oxide (Pb_3O_4).

Drinking water may be impregnated with lead. If it contains more than one-twentieth of a grain per gallon it is certainly unfit for use; and as different individuals differ much in their susceptibility to the action of lead, even smaller quantities may be harmful, especially if the use of the water is continued for some time. Ordinary water can be kept with safety in leaden cisterns, because the sulphates present in the water cause the formation of a thin film of insoluble sulphate of lead, and this forms a protective coating on the metal. Water destitute of salts, under similar conditions, soon becomes contaminated with lead, the oxygen in solution in the water forming an oxide of lead, which is slightly soluble. The presence of chlorides or nitrates in the water will lead to the presence of lead, as lead nitrate is freely, lead chloride slightly, soluble in water. Similarly, water containing carbonic acid becomes contaminated, for though carbonate of lead is insoluble in water, it is soluble in water containing carbonic acid. Distilled water, free from gases and salts, and kept out of contact with air, has no action on lead.

Symptoms of Acute Poisoning.—Metallic taste in mouth, with sense of constriction in throat; vomiting; severe colicky pains in abdomen; constipation (very rarely purging, with blood in the stools); prostration, etc.

Symptoms of Chronic Poisoning.—Colic, usually relieved by pressure; constipation; blue line on the gums; anæmia, and a sallow, cachectic appearance; wrist-drop, from paralysis of the extensor muscles: sometimes albuminuria.

Treatment.—In acute poisoning, the stomach must be emptied by the stomach-pump or by emetics. Soluble sulphates, *e.g.*, sulphates of sodium and magnesium, are antidotes, as they precipitate insoluble sulphate of lead, and then by their purgative action remove it from the body. White of egg and milk may be given, but the lead compounds which these precipitate are not absolutely insoluble, and hence emetics or purgatives must follow their employment.

To prevent chronic poisoning among workers in lead, factories should be well ventilated, the hands should be washed before taking meals, and a lemonade, made with sulphuric acid, be freely employed. The treatment of the condition, when developed, is the use of aperients (*e.g.*, magnesium sulphate), and the administration of potassium iodide (say five grains four times a day). Sulphur baths are also recommended. The paralysis needs electricity.

Post-mortem Appearances.—In acute poisoning there is more or less evidence of inflammation in the stomach and intestine. The gastric mucous membrane may be covered with whitish mucus in which the salt of lead may be detected.

Tests for Lead Acetate (*Solid*)—

1. Heated on charcoal in the inner flame of a blow-pipe, metallic globules (Pb), with a yellow incrustation of lead oxide, will be produced.

2. Dropped into a solution of KI it acquires a yellow colour.

3. Treated with H_2S, or NH_4HS, it becomes black.

Tests for Lead in Solution—

1. H_2S gives a deep black precipitate.

2. H_2SO_4: white precipitate, not a very delicate test.

3. HCl: white precipitate ($PbCl_2$), not soluble in, nor blackened by, NH_4HO. Chloride of silver is soluble in, and mercurous chloride blackened by, solution of ammonia.

4. KI: yellow precipitate soluble on boiling, redeposited on cooling as golden scales.

5. K_2CrO_4: yellow precipitate ($PbCrO_4$), which, on boiling with an alkali, becomes of an orange colour (Pb_2OCrO_4).

6. Galvanic test: place a few drops of the solution in a platinum capsule, acidulate with acetic acid; then touch the platinum through the fluid with a piece of zinc. Metallic lead is at once deposited.

7. Zinc introduced into the acidulated solution slowly displaces the lead. Lead is then precipitated as a dark blue spongy mass—*the lead tree.*

8. Cochineal test. Even a few drops of the solution will change the colour of water, tinged with cochineal, to a violet hue. This may be used as a convenient test for lead in drinking water; and by arranging a series of beakers containing a solution of cochineal, and treating these with equal quantities of water containing various (known) proportions of lead, a number of standards are obtained, with which the effect produced by the suspected water on the cochineal solution can be compared. The test thus has a certain quantitative value.

To detect Lead mixed with Organic Matter, etc.—

Acidify with HNO_3, boil and filter; through the filtrate pass H_2S, collect the precipitated PbS, dissolve in the smallest quantity of HNO_3, dilute, and test the solution.

Copper.—The best-known salts of copper are the sulphate (blue vitriol or blue stone) and the subacetate (verdigris). Sulphate of copper is given as a tonic or astringent in doses of one-quarter to 2 grains, and as an emetic in 5 to 10 grain doses. The nitrate is occasionally employed as a caustic. Chloride of copper may be produced when food containing chloride of sodium is prepared in copper vessels. All the salts are poisonous. A salt of copper is sometimes used to give a fresh green colour to tinned peas and other vegetables.

Symptoms.—Acute cases are rare. The sulphate has sometimes been used for homicidal purposes, but its strong metallic taste usually leads to its prompt discovery. It speedily, too, causes violent vomiting, with resulting rejection of the poison. The symptoms are those of gastro-intestinal irritation, the vomit being blue or green in colour. In addition, when the poison is absorbed, there may be paralysis or convulsions from the action of the poison on the nerve centres. Jaundice, too, has been observed. A form of chronic poisoning has occasionally been noted amongst workers in copper. The symptoms are—A metallic taste, *green* line on the gums (in some cases), irritability of alimentary canal, and wasting of the body.

Treatment.—After the stomach has been emptied by emetics, or the stomach-pump (if vomiting has not occurred under the action of the poison), milk or white of egg should be freely given. The precipitated albuminate of copper is not quite insoluble in the stomach, and should therefore be removed by an emetic or by washing out the stomach. Ferrocyanide of potassium and iron filings have also been recommended (see p. 137).

Post-mortem Appearances.—Very few fatal cases have occurred. Signs of inflammation, softening, and even ulceration of the mucous membrane of the stomach have been observed. The whole lining of the alimentary canal may have a greenish or bluish appearance. Perforation of the intestine has occurred.

Chemical Tests—

1. H_2S: a brownish-black precipitate, soluble in HNO_3 to a bluish fluid.

2. NH_4HO: light blue precipitate, soluble in excess to a deep blue fluid.

3. K_4FeCy_6: a gelatinous, reddish-brown precipitate.

4. Needle inserted in a solution (slightly acidulated with H_2SO_4) receives rapidly a coating of copper. The copper may be dissolved off with HNO_3, and the solution tested.

5. Galvanic test (see Lead): the stain on the platinum has the reddish colour of metallic copper.

Copper in Organic Mixtures.—The albumen and other substances present in the contents of the stomach precipitate copper. The compounds so precipitated, however, may be redissolved by the acid of the stomach. Hence, evidences of copper must be sought for both in the liquid and solid portions of the stomach contents. If the liquid is acidified, a needle may be placed in the solution, or the galvanic test be applied. Solid material should be made into a pulp with water, HNO_3 added, and the mixture boiled. The fluid obtained, after filtering, may be tested as above.

Note.—Commercial sulphate of copper sometimes contains traces of arsenic. Hence, if this salt has been used

as an emetic in any case, the vomited matters when tested may yield evidence of the presence of arsenic.

Zinc.—Sulphate of zinc (white vitriol) has been taken in mistake for magnesium sulphate (Epsom salts). A strong solution of zinc chloride, known as Burnett's Disinfecting Fluid, has also been taken, sometimes accidentally, sometimes with suicidal intent.

The *symptoms* of poisoning by zinc sulphate are those of gastro-intestinal irritation, viz., pain in the abdomen, prompt vomiting, and severe purging. In cases of poisoning by Burnett's fluid there will be evidences of corrosive action due to the zinc chloride, this being a powerful corrosive poison.

The *antidotes* are—White of egg to form albuminate of zinc, or sodium carbonate to precipitate insoluble zinc carbonate. The patient should partake freely of demulcent drinks. The marked emetic action of the poison, as a rule, renders the use of the stomach-pump unnecessary.

The *post-mortem appearances* show inflammation of the gastric and intestinal mucous membranes; and if the chloride of zinc has been taken, evidences of its corrosive power will be found in the mouth, pharynx, and œsophagus.

Tests—

1. NH_4HS: in a neutral or alkaline solution gives a white precipitate of zinc sulphide. This is a very characteristic test, zinc sulphide being the only white sulphide that will be met with.

2. NH_4HO: a white precipitate of zinc hydrate soluble in excess.

3. K_4FeCy_6: a white gelatinous precipitate of ferrocyanide of zinc.

The tests 1 and 3 distinguish zinc sulphate from magnesium sulphate, the latter giving no precipitate with either of these reagents. The two salts have the same crystalline form. The taste of the zinc salt is metallic and astringent; that of magnesium sulphate, bitter.

To detect zinc in the contents of the stomach or other organic mixtures, these should be digested with dilute acetic acid, and the filtrate evaporated, the residue dissolved in water, and tested.

Silver.—Poisoning has occasionally occurred from the accidental swallowing of silver nitrate (lunar caustic). The *symptoms* are those of severe gastro-intestinal irritation, the vomit often containing blood. The *antidote* is common salt, which forms insoluble silver chloride; the stomach should subsequently be washed out by the use of demulcent drinks.

Tests—

1. HCl: a white curdy precipitate (AgCl), insoluble in nitric acid, soluble in solution of ammonia.

2. KHO: a brown precipitate of silver oxide.

3. K_2CrO_4: a red precipitate of chromate of silver.

4. Sodium phosphate: a pale yellow precipitate of phosphate of silver.

Cantharides—*Synonym*, Spanish Flies.—This is an irritant poison of animal origin. The active principle is *cantharidin*. It forms about $\frac{1}{250}$th part of the flies. It is a neutral, crystallizable principle, insoluble in water,

slightly soluble in alcohol, and freely soluble in chloroform, ether, and some fixed oils. From cantharides is prepared an official tincture—strength, 6 grains to the ounce; dose, 5 to 20 minims. The powdered flies themselves and the tincture have each been employed for poisonous purposes. Symptoms of poisoning, too, may follow the application to the skin of a fly-blister if absorption of the cantharidin occurs.

Cantharides has but seldom been employed for directly poisonous purposes. It is given, however, to produce criminal abortion, and sometimes for its supposed aphrodisiac influence. Twenty-four grains of the powder, and one ounce of the tincture, are the smallest fatal doses recorded, but much larger quantities have been taken without producing death.

Symptoms.—There are evidences of gastro-intestinal irritation, and also of irritation in the genito-urinary passages. Retching, vomiting (often bloody), some abdominal pain, and purging, with blood and mucus in the stools, are to be expected. If the *tincture* has been given, there will be pain in the throat, and the symptoms will appear promptly. The vomited matter and stools may contain particles of the shining, greenish, wing-cases if the *powder* has been swallowed. After a time there will probably be pain in the loins, a sense of heat in the bladder, priapism, strangury, and albuminous or bloody urine. In pregnant women abortion may result. This is rather the result of the general disturbance than of any specific action of the poison on the uterus. In fatal cases death has been preceded by convulsions.

Treatment.—Vomiting must be promoted. There is no antidote. Fixed oils are contra-indicated, as they promote

solution of the cantharidin. Opium is often useful. Large quantities of demulcent drinks, such as barley-water, by diluting the urine, will lessen the irritating action of the poison on the genito-urinary tract.

Post-mortem Appearances.—Few fatal cases are recorded. Signs of irritation in the alimentary canal and in the kidneys, ureters, bladder, and organs of generation have been observed. Instead of inflammation in the stomach, the mucous membrane has been found soft and pulpy. The wing-cases, if the powder has been given, may be detected in the stomach. The contents of the stomach should be treated with boiling water; the wing-cases sink to the bottom of the fluid.

Analysis.—Digest the solid or liquid contents of the stomach (evaporated to an extract) with successive portions of chloroform or ether. A solution of cantharidin is thus obtained. Allow the fluid to evaporate, and apply the residue to the lip or lobe of the ear. If cantharidin is present, it will produce a blister. It is said that $\frac{1}{100}$th grain of cantharidin dissolved in ether will, when applied to the lip, produce vesication in fifteen minutes. A negative test of some value is the fact that neither nitric nor sulphuric acid, applied to the residue left after evaporation of the above solution, produces any change in colour. This distinguishes cantharidin from the principal vegetable alkaloids.

Hydrocyanic Acid—*Synonym*, Prussic Acid (HCN, HCy).—The official *Acidum Hydrocyanicum dilutum* contains 2 per cent. of anhydrous HCN, *Scheele's Acid* 4 to 5 per cent. Hydrocyanic acid is also present in *Aqua*

Laurocerasi B.P. to the extent of 0·1 per cent. It is also produced when bitter almonds or wild cherry bark is treated with water. Hence the presence of the acid in "essential oil of bitter almonds," and in syrup and tincture of Virginian prunes. The essential oil of bitter almonds, freed from the acid and dissolved in spirit, is known as *Ratafia.* It is used as a flavouring agent by confectioners, etc. The kernels of the fruits of the peach, cherry, apricot, plum, and apple, yield hydrocyanic acid when bruised in the presence of water. Cyanide of potassium is a very poisonous salt of hydrocyanic acid. It is used in photography.

Anhydrous hydrocyanic acid is a most deadly poison, the inhalation of its vapour being almost immediately fatal. It is not a stable substance, and it is the preparations above described—more especially the first two—that are of medico-legal importance. The smallest dose known to have proved fatal is 30 minims of the B.P. acid, equal to six-tenths of a grain of anhydrous acid. Death usually occurs in a few minutes, almost always in less than half-an-hour. If the patient lives longer than this he ought to have a good chance of recovery, though death has occurred as late as an hour after the poison has been taken.

Poisoning by hydrocyanic acid is generally either accidental or suicidal. The strong odour interferes with its use for homicidal purposes.

Symptoms.—When a large dose has been taken, death may be almost immediate. In other cases, such symptoms as the following may be expected :—

1. Hot, bitter, taste, with a sense of constriction in the throat.

2. Loss of consciousness and voluntary power. This may occur immediately. On the other hand, cases have been recorded in which, even after large doses, the victim has been able to perform such voluntary acts as calling for assistance, crossing a room, etc. This is a consideration of importance in determining whether the case is one of suicide or homicide.

3. Eyes usually fixed and staring, with pupils dilated and insensitive to light. There may be foaming or frothing at the mouth.

4. Respiration hurried, convulsive; sometimes stertorous, as in apoplexy.

5. Pulse weak or imperceptible, the skin cold and clammy.

6. Convulsions frequently precede death.

Note.—The odour of the acid aids the diagnosis.

Treatment.—The poison is so rapidly absorbed that the chief attempts at treatment must be to counteract its effects, *i.e.*, to stimulate the cardiac and respiratory systems. This may be attempted by cold affusion to the spine, the application of ammonia to the nostrils, the administration of stimulants, and artificial respiration. Apomorphine may be used as an emetic, and atropine by subcutaneous injection may be useful in consequence of its stimulating action on the respiratory centre. The antidote is a mixture of a ferrous and ferric salt (*e.g.*, $FeSO_4$, and Fe_2Cl_6), followed by potassium carbonate. The result is the formation of Prussian blue, which is inert. But the time involved in obtaining and administering such a mixture means that in the majority of cases it must be too late to be of service. And as the jaws are often firmly clenched, it is difficult or impossible to give anything by the mouth.

Post-mortem Appearances.—The face is pale or livid, and lividity may be seen in the lips and nails, the eyes staring, the jaws firmly closed, and the fingers clenched. Internally, the venous system and viscera are engorged with dark-coloured fluid blood. In some cases the blood is bright red, due, it is said, to a compound formed by the union of cyanogen with hæmoglobin; the spectrum is not especially characterised by any band (Luff). The stomach and intestines may appear healthy, or the mucous membranes may be congested or reddened. The odour of the acid may be very manifest in the stomach, etc. But the absence of this does not necessarily negative the suggestion of death from poisoning by prussic acid, for the acid is so volatile that it may have all disappeared before the dissection is performed, or its odour may be concealed by other odorous substances which are present.

Tests for Dilute Hydrocyanic Acid—

1. Physical properties. Is a colourless, watery fluid with a characteristic odour. Inhaled, it produces a sense of constriction at the back of the throat. In reaction, it is slightly acid.

2. $AgNO_3$: a white curdy precipitate (AgCy), insoluble in cold, soluble in boiling HNO_3. Collect the precipitate, dry, heat in a reduction tube—cyanogen gas is given off. This may be ignited; the flame has a characteristic peach-blossom tint. To test for the *vapour* of HCN as, for example, in an organic mixture, a drop of the silver solution is placed on a blackened watch-glass which is inverted over a vessel in which the suspected substance is contained. Immediately, or in the course of a few minutes, silver cyanide is precipitated.

3. The Iron test. Neutralise with KHO, then add a mixture of $FeSO_4$ and Fe_2Cl_6; a dirty green precipitate falls. Now add HCl; a precipitate of Prussian blue is obtained. This test may be adapted to detect the *vapour* of HCN by putting a drop of KHO on a watch-glass, and inverting this over the suspected fluid. After a time touch the KHO with a drop of the mixed iron solutions and add HCl: Prussian blue will be precipitated.

4. The Sulphur test (Liebig's test). Add a few drops of yellow sulphide of ammonium to the hydrocyanic acid solution, and heat in a water bath to leave a dry residue. To this add a drop or two of solution of ferric chloride—a blood-red colour (Fe_26CyS) is produced. This is at once discharged by a solution of mercuric chloride, which distinguishes the ferric sulphocyanide from ferric meconate (see p. 152). This test is very delicate and is very suitable for the "watch-glass" method.

Hydrocyanic Acid in Organic Liquids—

The tests, as far as the contents of the stomach are concerned, may all fail if the body has been exposed for several days. Put the organic mixture in a wide-mouthed bottle to which a watch-glass may be fitted as a cover. The bottle should be filled to such a level that the fluid is within 1 or 2 inches of the surface of the watch-glass. Then apply the tests for the vapour of the acid. The vessel containing the organic matter may be placed in warm water so as to promote the ascent of the vapour of the acid.

Another method is to faintly acidulate with tartaric acid and distil from a water bath. Test the distillate as above. If the viscera have undergone putrefaction, both the above

methods may fail, as the acid may have been converted into sulphocyanide of ammonium. By treating with alcohol and evaporating the solution, this salt may be detected on adding ferric chloride (see p. 145).

Note.—There is a certain amount of resemblance between an epileptic fit and a case of poisoning by hydrocyanic acid. The history of previous attacks, the occurrence of an aura, the abrupt and violent onset of the convulsions, and the comparatively prompt return of the patient to consciousness, distinguish an ordinary epileptic seizure. In those rare cases in which epilepsy is the direct cause of death the *status epilepticus* is prolonged for many hours, whilst hydrocyanic acid, if fatal, produces death much more rapidly—almost always within half-an-hour.

Chloroform.—Suicide may be committed by the inhalation of chloroform, or death may be accidental, an individual using the anæsthetic to relieve pain or procure sleep and unintentionally taking an overdose. A person may be chloroformed for the purpose of facilitating robbery or some other crime; this could scarcely be accomplished by an unaided individual unless the victim was very weak or was in a deep sleep. An attempted administration in the latter state usually arouses any one. Statements to the effect that an individual was rendered unconscious by a handkerchief waved in front of his face are of course fictitious; it takes several minutes of steady inhalation of chloroform to render a person unconscious. Occasionally the poison has been swallowed for suicidal purposes or by accident, and rarely it has been used with homicidal intent.

The *symptoms* are—Unconsciousness, with evidences of cardiac and respiratory failure. The breathing is often stertorous; the pupils are dilated and insensitive. If the poison has been swallowed, its irritant action on the gastric mucous membrane will probably cause vomiting.

Treatment includes the usual methods adopted when danger threatens during surgical anæsthesia, *e.g.*, lowering of the head, artificial respiration, inhalation of amyl nitrite, etc. In addition, if the poison has been given by the stomach, the stomach pump or an emetic is indicated.

Post-mortem examination may show redness of the gastric mucous membrane, but there are no characteristic appearances. The odour may be recognised in the stomach or other viscera, and the chloroform obtained from these by distillation.

Chloral Hydrate.—This is largely used as a hypnotic, and the chloral habit is not very uncommon. Poisoning by chloral hydrate is more frequently suicidal or accidental than homicidal, but cases of homicide have been reported. Twenty grains have proved fatal to an adult, but much larger doses have often failed to cause death. Habit produces a certain degree of tolerance. On the other hand, fatty or other degenerative changes in the heart render patients very susceptible to the action of chloral.

The *symptoms* are—Drowsiness, passing on to coma, with marked depression of the action of the heart and of the respiration; the pupils are generally contracted and insensitive to light.

Treatment, after emptying the stomach, includes endeavours to arouse the patient; stimulants (*e.g.*, strong coffee),

and warmth to the surface; hypodermic injection of strychnine to stimulate the respiratory centre; and, if necessary, artificial respiration and the inhalation of oxygen.

The *post-mortem* appearances indicate cardiac and respiratory failure, but there is nothing distinctive. To detect chloral hydrate in the contents of the stomach Luff gives the following directions: Digest for twenty-four hours with three or four times their volume of absolute alcohol rendered acid by sulphuric acid; then filter and evaporate. Shake the residue repeatedly with petroleum ether to remove fatty substances, and then with ordinary ether, which extracts the chloral hydrate. On evaporation of the ether the chloral is left. Chloral hydrate is freely soluble in water; and the solution, shaken with caustic potash and gently warmed, gives off the odour of chloroform. It is eliminated partly unchanged in the urine, and can be obtained from that fluid by acidifying with sulphuric acid, shaking with petroleum ether, and then adding ordinary ether, which extracts the chloral hydrate.

Opium.—This, in the form of some of its preparations, is frequently used for poisonous purposes. Some of the best-known preparations are—*Tinctura Opii* (Syn. Laudanum), 33 grains of opium in the fluid ounce, *i.e.*, 1 grain of opium in 15 minims nearly; *Pulv. Ipecacuanhæ Co.* (Dover's Powder), 1 in 10; *Tinct. Camphoræ Co.* (Paregoric), 2 grains of opium in the fluid ounce. *Nepenthe* and *Battley's Solution* are also active (non-official) preparations of opium. Syrup of poppies, chlorodyne, various "soothing syrups" and cough mixtures, contain opium or its alkaloid, morphine. There are various solutions of mor-

phine used medicinally, and the hypodermic employment of the alkaloid is a frequent practice with those who become addicted to the use of this poison.

Fatal Dose.—The smallest dose of *opium* which has proved fatal to an adult is 4 grains; of the tincture, 2 fluid drachms. In children, and especially in infants, very small doses—even a fractional part of a grain—have proved fatal. Children are very susceptible to the influence of opium. But both in adults and children even large doses have been found compatible with recovery.

The time when symptoms first appear is, as a rule, from half-an-hour to an hour after the poison has been taken. If the dose is large, and especially if the poison is in solution, symptoms may appear very promptly. On the other hand, a full stomach, a state of intoxication, etc., may delay the symptoms. Habit and idiosyncrasy considerably modify the effects of the poison. In disease of the kidneys a very small quantity of opium may produce fatal effects.

As a rule, in fatal cases, death occurs in from six to twelve hours; if the patient should live longer than this his chance of recovery is good. The medicinal dose of opium is a half to two grains; of laudanum, 10 to 30 minims. The minimum fatal dose of a morphine salt is half a grain of the acetate. The symptoms are similar to those produced by opium, but convulsions are more likely to occur. If the poison is injected hypodermically the symptoms will appear with marked promptness.

Symptoms.—There may for a short time be evidences of stimulation, such as a quick pulse, brightness of the eyes, fulness in the head, with giddiness. Soon, however, the narcotic effects of the poison appear. There is drowsiness,

gradually increasing in intensity, and passing on to stupor. In this state the patient may still be roused. He lies quiet and motionless, with closed eyes, the face pale and with an expression of repose, the skin moist, the muscles relaxed, the pupils contracted, the pulse feeble, and respiration slow. In fatal cases the stupor deepens into coma, with stertorous breathing, and the pupils may become dilated, but still insensitive to light. Rarely death is preceded by convulsions. Sometimes there is vomiting, and, if this occurs before stupor sets in, there is good hope of recovery.

Treatment.—To remove the poison, wash out the stomach, or, if the stomach pump is not at hand, use emetics. One of the best of these under the circumstances is mustard (say one or two table-spoonfuls) and water, for even should the depressant action of the poison be so marked that the stomach will not respond, the retention of the mustard can do no harm; indeed, being a stimulant, it may so far do good.

The patient must be roused up by walking him about, shaking him, etc., but this should not be over-done, as it tends to exhaust the patient. Artificial respiration may be necessary, and some recommend strychnine (one-thirtieth grain) hypodermically to stimulate the respiratory centre; inhalation of oxygen may be tried if there is much cyanosis. Strong coffee is also given for its stimulant action. Solutions of tannin have a certain value as antidotes, but the precipitate they give is to some extent soluble in the fluids of the stomach.

The physiological antidote is atropine. It may be administered by hypodermic injection. One-twentieth of a grain of the sulphate may be given in the first place,

and the dose repeated according to its effect on the pupil. Atropine, by its stimulating action on the respiratory centre, tends to prevent the depressing influence of opium on that centre, which is one of the chief dangers in opium poisoning.

Post-mortem Appearances.—These are far from characteristic. The stomach is generally normal, but the odour of opium may perhaps be detected in its contents; if morphine has been taken there will be no characteristic odour. Congestion of the vessels of the brain, with serous effusion into the ventricles and at the base, may be, but is not always, present. The lungs are generally engorged, and the blood fluid.

Chemical Tests.—There are no direct tests for opium. The principal poisonous constituent of opium is morphine, which exists in the drug in combination mainly with meconic acid, and it is by getting a response to the tests for morphine and for meconic acid that the presence of opium is detected.

Tests for Morphine—

1. Physical properties. It crystallises in fine white prisms, has a bitter taste, is very slightly soluble in cold water, but is soluble in boiling water, in dilute acids, and also in alcohol and in ether. The *salts* of morphine are much more soluble in water.

2. Heated on platinum, the crystals melt, take fire, and burn with a yellow flame, producing much smoke and leaving a black mass.

3. HNO_3 dissolves it with effervescence, giving off red fumes, and leaving an orange-red stain.

4. H_2SO_4 and $K_2Cr_2O_7$ = green colour. (Narcotine also

gives a green colour; but, when the sulphuric acid is added alone, narcotine becomes a bright yellow, whilst morphine is either unaffected or takes on a faint pinkish tinge.)

5. Sulphomolybdic acid: dissolve a few grains of molybdic acid in a little strong sulphuric acid by the aid of heat. A drop or two of this freshly made solution rubbed with dry morphine or any of its salts gives a purple or crimson colour, which changes to green and afterwards to sapphire blue. It is the first coloration which is characteristic. With strychnine the test at first produces no change, but in time a pale blue tint appears.

6. Fe_2Cl_6 gives a bluish or greenish-blue inky colour to a solution containing morphine. This colour is bleached by HNO_3, and the acid in excess produces an orange colour.

7. Iodic acid: mix a drop of iodic acid solution with twice its volume of chloroform. Add a little of this to the morphine solution. Iodine is separated and is dissolved by the chloroform, which acquires a pink or red colour, and sinks to the bottom of the test tube. Or iodic acid may be employed without the chloroform, and the free iodine detected by starch paper. This test is a convenient one to apply to any organic fluid believed to contain morphine.

Tests for Meconic Acid—

1. This occurs in small, nearly colourless, micaceous crystals, readily soluble in alcohol, sparingly so in water.

2. Fe_2Cl_6 gives to the solution a blood-red colour which is *not* discharged by solution of mercuric chloride. The last feature is of importance, because sulphocyanides (found

in the saliva) also give a blood-red colour with Fe_2Cl_6, but this *is* discharged by solution of mercuric chloride.

This test may be applied to any organic fluid believed to contain opium. After dilution of the fluid, the addition of the Fe_2Cl_6 solution will produce a blood-red colour if opium is present.

Detection of Opium in Organic Mixtures—

The odour of opium may or may not be present.

If the organic mixture is liquid it should be evaporated to the consistence of a soft extract; if solid, cut into slices or reduced to a pulp. It should now be digested for some hours in rectified spirit acidified with acetic acid. The liquid after filtration is evaporated to dryness, and the residue digested in absolute alcohol. The solution so obtained is filtered, and the filtrate again evaporated to dryness. The residue is now shaken up with warm water, filtered, and to the filtrate lead acetate is added until a precipitate ceases to form. Now filter. Acetate of morphine passes through, lead meconate remains on the filter.

To Test the Filtrate.—Pass H_2S to throw down excess of lead; filter out the precipitated PbS. Evaporate to a pulp, and from this extract the morphine by alcohol, and apply tests as above.

To Test the Filter.—Heat with dilute H_2SO_4; filter out the precipitated lead sulphate. Test the solution (which contains meconic acid) as above.

The examination of the contents of the stomach or other organic mixture for morphine or other alkaloid requires both care and experience, and in cases of any importance is undertaken by a chemical expert. But the medical practitioner should at least understand the prin-

ciples of the methods employed, and also be practically familiar with the responses to the usual test reagents.

Condition of the Pupils in Poisoning.—In opium poisoning the pupils are contracted unless shortly before death, when they may be dilated. Carbolic acid also contracts the pupil. Calabar bean has the same effect. In alcoholic coma the pupils are contracted, unless the patient has recently been disturbed; on moving him or shaking him the pupils dilate, and then gradually again contract in the course of five to twenty minutes (Macewen).

Belladonna, hyoscyamus, and cocaine dilate the pupils.

In apoplexy the pupils are usually dilated or unequal, but if the seat of hæmorrhage is the pons varolii they may be contracted. An attack of apoplexy sometimes seems to be determined by the taking of food. It may come on during or immediately after a meal, whilst the symptoms of opium poisoning do not appear for half-an-hour or so after the poison has been taken, and they develop gradually. In apoplexy the stupor is apt to be pronounced from the onset, the patient manifesting no response to stimuli.

The odour of opium or of carbolic acid in the breath would assist the diagnosis in cases of poisoning by these substances. The odour of alcohol in the breath is of little value for diagnostic purposes, as it is common to find that alcohol has been given with therapeutic intent, whatever be the cause of the comatose condition.

Strychnine.—This poisonous alkaloid is obtained from nux vomica seeds. It also exists in the St. Ignatius' bean. In both of these it is associated with a similar but less poisonous alkaloid—viz., *Brucine.*

There is an official *Extractum Nucis Vomicæ* containing 15 per cent. of the alkaloids—dose, a quarter to 1 grain; also an official *Tinctura*, each fluid ounce of which contains 1 grain of the alkaloids—dose, 10 to 20 minims. *Liquor Strychninæ Hydrochloratis* (B.P.) is a 1 per cent. solution; the dose is 5 to 10 minims. Strychnine is also an ingredient of Easton's syrup—one thirty-second of a grain in a fluid drachm. It is the active constituent of Battle's vermin killer and other similar preparations. The powdered nux vomica seeds are sometimes employed to destroy mice.

Though strychnine has a very bitter taste, the dose required to produce death is so small, that it may be readily given for homicidal purposes in the form of pills, or may be professedly administered as quinine or other bitter medicine. The smallest dose which has proved fatal is half a grain, and recovery after 1 to 2 grains is exceptional.

The symptoms usually appear in from five to twenty minutes, but cases are on record—more especially when the poison has been administered in the form of a pill—in which the symptoms have been postponed for an hour or longer. Death may occur in the course of a few minutes, or several hours may elapse before the fatal event.

Symptoms.—There is at first a sense of uneasiness and anxiety, with a feeling of impending suffocation, and quiverings or twitchings of the muscles of the limbs. Then sudden and violent muscular spasms (clonic) set in, the hands are clenched, the limbs stretched out, and the back arched (opisthotonos). At the same time, there is spasm of the respiratory muscles, with lividity, staring eyeballs, dilated pupils, and perhaps foam at the mouth. Then after

one or two minutes the convulsive seizure terminates, the patient feels exhausted, sweats freely, and is perhaps inclined to sleep. The spasm is, however, soon renewed, it may be under the influence of some external stimulus, as a draught, noise, attempts to drink water, etc.; or the patient may be conscious of its approach. These attacks are more or less rapidly repeated, and death may occur from spasm of the respiratory muscles (asphyxia) or from exhaustion (asthenia). The intellect remains clear, and there is often an acute sense of impending death. The bodily temperature may be raised far above the normal.

Strychnine acts on the motor centres in the spinal cord, increasing their reflex irritability; hence the development of severe and general convulsions under the influence of any slight external stimulus.

Treatment.—Emetics may be given, but the use of the stomach pump is not desirable as it is likely to excite spasm. As antidotes, tannin (25 parts for 1 of the poison), and iodine in solution of potassium iodide, may be given. The resulting precipitates are to some extent soluble, and should therefore be evacuated by emetics. Chloral or chloroform is needed to control the spasms. If the patient cannot swallow, chloral dissolved in water may be given *per rectum.*

Post-mortem Appearances.—These will vary with the mode of death, and there are none characteristic. The body may or may not be rigid. In some cases there are the evidences of death by asphyxia, the right heart, lungs, and veins being full of dark fluid blood. Sometimes the heart is contracted and empty. Congestion of the brain and upper part of the spinal cord has also been noted.

Tests for Strychnine—

1. Occurs in elongated prisms, white or cream-coloured, very slightly soluble in water, but sufficiently so to give to the solution a distinctly bitter taste (characteristic). It is soluble in rectified spirit and freely so in chloroform. Acids form with strychnine soluble salts.

2. H_2SO_4 does not affect the colour, but on adding a crystal of $K_2Cr_2O_7$ a play of colours—blue, purple, violet, red, slowly fading—is produced. MnO_2 with sulphuric acid will have the same effect. The presence of morphine in large amount interferes with this reaction. Further, it may be noted that H_2SO_4 gives a pink colour to salicin, and also a colour reaction with veratrine, curarine, etc.

Tests for Strychnine in Solution—

$K_2Cr_2O_7$: a flocculent yellow precipitate.

Picric acid: a precipitate of small tufts or groups of stellated crystals (Taylor).

Frog test: a few drops of a solution of strychnine injected below the skin are soon followed by convulsions; various substances other than strychnine cause convulsions, hence the negative result of the test is alone reliable.

Strychnine in Organic Mixtures—

Add acetic acid and rectified spirit to the contents of the stomach or to the solid viscera (cut small), and digest for an hour in a water bath. Filter, and proceed as described in connection with the detection of morphine so as to get a solution of acetate of strychnine. Now add KHO to the fluid; strychnine (the alkaloid) is precipitated. Shake up with chloroform, which dissolves the strychnine. Allow this solution to evaporate; the strychnine remains in the crystalline form and may be tested as above.

The residue left after the first filtration may be digested with rectified spirit and tartaric acid to dissolve out any strychnine it may contain (Stas's process).

Strychnine does not readily undergo decomposition; it may be detected in the viscera months or even years after death.

Brucine.—This produces similar symptoms to those due to strychnine. It is a much less powerful poison than that alkaloid. It does not respond to the colour test for strychnine, but gives a blood-red colour with nitric acid.

Tetanus.—In this disease there are marked muscular spasms. There is a history of injury which may, however, be slight. The spasm comes on gradually, not suddenly, and first affects the muscles of the lower jaw (trismus). The spasm is of the tonic order—there are no intermissions; at most, remissions are observed. The disease lasts for several days as a rule; very rarely death occurs within twenty-four hours. By these features tetanus is distinguished from strychnine poisoning.

Epilepsy.—The patient is unconscious, and succeeding the convulsion is in a stuporose condition, and often falls into a deep sleep—a marked contrast to the clear mental state that is found in strychnine poisoning. There may be a history of previous attacks.

Vegetable Poisons.—The following, in addition to those already discussed, may be noted:—

Belladonna, Deadly Nightshade.—This causes dryness of the mouth and throat, dilatation of the pupils with indistinctness of vision, and delirium leading on to stupor. Its active principle is an alkaloid—*atropine.* The physiological antidote is opium.

Aconite, Monkshood.—The root has been used in mistake for horse-radish. It is, however, short, and rapidly tapers to a point; has a brownish colour; and when chewed, gives, in ten minutes or so, a sense of tingling, followed by numbness of the lips and tongue. Horse-radish root, on the other hand, is long and cylindrical; yellowish-white in colour; has a pungent odour when scraped; and communicates at once a hot or pungent taste. The most characteristic symptom of aconite poisoning is the sense of tingling, going on to numbness. There are also the evidences of collapse, the drug being a powerful cardiac depressant. Free stimulation, the recumbent posture, and the use of digitalis and strychnine, are suitable measures to adopt as treatment. *Aconitine*, the active principle, is a most formidable poison—probably one-twentieth of a grain is sufficient to cause death.

Poisonous Fungi.—The symptoms these produce are of the narcotic order, with more or less irritation in the alimentary tract.

Animal Poisons.—Flesh meat of any kind, if in a putrescent condition, may cause symptoms more or less like those due to an irritant poison. In some cases, such symptoms, together with general prostration and cardiac weakness leading even to death, have followed the ingestion of animal food not manifestly in a state of putrefaction. Shell-fish (*e.g.*, mussels), sausages, and pork, are the articles of food which have most frequently produced these results. It is probable that the poisonous agents are *ptomaïnes* or *cadaveric alkaloids*, produced by the chemical changes of commencing decomposition.

INSANITY.

The following brief notes are offered on this subject:—

Insanity, as a condition, presents features so numerous and varied, both in kind and degree, that no exact definition of it is possible. In all cases of true insanity the intellect is more or less affected—there are indications that the reason is disturbed. The faculties of attention, judgment, or volition may be disordered, and this state may or may not be accompanied by an abnormal condition of the moral sentiments, *e.g.*, causeless suspicion, cruelty, hatred, or jealousy. Delusions and hallucinations, though common, are not always present.

Hallucinations are sensations which the patient believes are due to external impressions, though no corresponding material object is at the time acting on the senses. When an object acting on the senses is falsely perceived, and the patient's power of judgment is so affected that he believes and acts upon this false impression, he suffers from a *delusion* and is certainly insane. *Illusions*, that is the false perception of external objects, but the rectification of this false perception by the action of the other senses and of the judgment may be met with in the sane. In *hallucinations* and *delusions* the patient *believes* something to exist which does not exist; in *illusions* the patient's judgment corrects the absurd or erroneous impression conveyed through the senses, and therefore he does not believe in or act upon it.

Moral Insanity is the condition in which the moral

sentiments (emotions, passions, etc.) are perverted, but this is not accompanied by any delusion, hallucination, or mental aberration. If such a condition ever exists, it cannot be distinguished from moral depravity, and the law does not recognise it.

The forms of insanity may be classified as follows:—

I. *Dementia naturalis*, or *Idiocy*.

II. *Dementia adventitia*, or *Lunacy*, comprising—
Mania, Monomania, Dementia.

General paralysis of the insane is a cause or symptom of insanity, not a separate division of it.

IDIOCY is congenital deficiency or absence of the mental faculties; there are never any lucid intervals. *Imbecility* is merely a minor degree of idiocy; the patient has some mental power, and is susceptible of a certain degree of mental and moral culture.

MANIA is general derangement of the mental faculties, with a greater or less degree of excitement, which in some cases amounts to violent fury. Maniacs may be comparatively insensible to violence, extremes of heat and cold, etc., and may thus inflict fearful injuries upon themselves. *Melancholia* may be regarded as chronic mania.

MONOMANIA is mental disorder confined to a single subject or class of subjects. The *monomaniac* shows a distinct change from his former character, and cannot be convinced that his ideas are inconsistent with reason or with the general conduct of mankind. The merely *eccentric* individual has always been more or less peculiar, admits his peculiarity, but defies the judgment of society.

DEMENTIA is the more or less complete abolition of all intellectual and reasoning power; memory is absent or

momentary, or confined to events long since past. *Senile dementia* is sometimes termed "the imbecility of age."

Lucid Intervals are periods of temporary but, for the time being, complete cessation of the insanity; they must not be mistaken for mere remissions of the symptoms. They are met with in mania and monomania, rarely in dementia, never in idiocy. The individual, during a lucid interval, has the same legal rights and responsibilities as a person who has never been insane.

In law, the terms *Idiocy* and *Lunacy* are employed, and one of the most important *legal* proofs of insanity is the existence of *delusions;* that is, the person systematically believes something to exist which does not exist, maintains his conviction in spite of clear evidence to the contrary, and acts upon it. In medical certificates, the phrases *Insanity* and *Unsoundness of Mind* are practically synonymous, though, in law, the latter term is more especially applied to an individual who, "in consequence of some morbid condition of his intellect, is unable to manage his affairs with ordinary care and propriety." It assumes legal relationships in connection with such acts as the making of a will, entering into a contract, etc.

The admission or rejection of a plea of insanity advanced in answer to a criminal charge is, in some cases, a matter of great difficulty, as the medical and legal views of what constitutes insanity do not exactly correspond; and the recognition of insanity and its distinction from mere pretence is not always easily accomplished. According to the legal theory, every person is responsible, and can be punished, for an illegal action, unless it can be shown that, in consequence of some dis-

ease affecting his mind, he is prevented (*a*) from knowing the nature or quality of his act, or (*b*) from knowing it is wrong. But medical men are aware of the fact that there are persons who are quite capable of appreciating these distinctions, yet are undoubtedly insane. Such a person may commit an illegal act under the influence of an "uncontrollable impulse"; that is, an impulse which, owing to the mental disease, his reason has not sufficient power to control. If this were proved, it is probable an acquittal would be secured; but care must be taken (and here is the difficulty) to distinguish between an *irresistible* influence and one which is merely *not resisted.*

The following points may be borne in mind in endeavouring to determine whether a person charged with an illegal act is or is not insane: Family history, as giving evidence of insanity, epilepsy, etc.; the existence of any circumstance in the personal history which might act as an exciting cause of insanity, *e.g.*, alcohol, injury to the head, mental worry, etc.; any decided peculiarity of temperament or behaviour or character displayed *before* the act was committed; any *known* motive (insane people may injure or kill those to whom they are most attached, and often have several victims); the existence of a delusion such as might lead him to commit the act he is charged with; behaviour as regards concealment of his act, accomplices, confession, general conduct, etc. The existence of delusion having no obvious connection with the act would scarcely free a prisoner from criminal responsibility. Persons feigning insanity generally overact the part, and "keep it up" only, or especially, when they believe they are under observation—a genuine lunatic usually strongly

protests that he is sane. Each case must be judged on its merits, and the medical man must be prepared to adduce reasons for the opinion he expresses.

Restraint of the Insane.—A medical man may be requested to certify that an individual is insane or of unsound mind and a proper person "to be taken charge of and detained" in an asylum. If he does so on insufficient grounds, or without fulfilling all the legal requirements, he may be found liable in damages to the person concerned. There is a special form of certificate provided for the purpose, and the marginal directions in this must be carefully attended to. It is necessary that the reasons upon which the conclusion is formed shall be stated, and some of these must be *facts* observed by the practitioner himself. Two medical certificates are required, and the medical men signing them must be registered, must not be in partnership with each other, and a medical certificate is not valid if one of the practitioners is an assistant to the other. Each practitioner, too, must have examined the patient separately from the other, and the examination must have been conducted within seven clear days of admission to the asylum. No medical practitioner associated with an institution for care of the insane can certify a patient who is to be placed in that institution. The medical certificates, together with a statement giving full particulars of the case, are submitted in support of a "petition" presented by the nearest relative or other competent person to a "judicial authority" praying for an "order" to authorize the confinement of the patient. If the "judicial authority" grants the "order," this constitutes the legal warrant for the detention of the lunatic.

The "judicial authority" in *Scotland* is the sheriff of the county; in *England*, either a justice of the peace "specially appointed for the purpose," a stipendary magistrate, or a county court judge. In cases of emergency, a certificate signed by one medical man is sufficient to secure the admission of a patient to an asylum, but this certificate is only efficient for a period of three days (in *England*, seven days). Unless within that period the two certificates and the judicial order above referred to are provided, further detention of the patient is illegal.

No medical man can receive into his house any insane person, whether for medical treatment or otherwise, unless he has previously obtained a license from the Commissioners in Lunacy and the usual certificate signed by two other medical men.

It is most important that every medical man should be acquainted with the provisions of the law affecting the restraint and detention of insane persons. Ignorance of these may lead a medical man to commit mistakes which may cause him worry and annoyance, and may involve him in serious legal penalties. It is therefore his interest as well as his duty to familiarise himself with the particulars which the law demands.

CHEMICAL FORMULÆ.

The following is a list of the Chemical Formulæ used in the foregoing pages, with the names of the substances they respectively represent:—

Ag	... ...	Silver.
AgCy	...	Silver cyanide.
Ag_3AsO_3	...	Silver arsenite.
Ag_3AsO_4	...	Silver arseniate.
$AgNO_3$	...	Silver nitrate.
As	... ...	Arsenium (metal).
AsH_3	... ...	Arseniuretted hydrogen.
As_2O_3	..	Arsenious acid; arsenious anhydride; white arsenic.
As_2O_5	...	Arsenic acid.
As_2S_3	...	Arsenium sulphide.
$AuCl_3$	...	Chloride of gold.
$BaCl_2$	...	Barium chloride.
BaS	... ...	Barium sulphide.
$BaSO_4$	...	Barium sulphate.
C	... ...	Carbon.
CH_4	... ...	Marsh gas; light carburetted hydrogen.
CO	... ...	Carbonic oxide; carbon monoxide.
CO_2	... ...	Carbonic acid gas; carbon dioxide.
CaC_2O_4	...	Calcium oxalate.
$CaSO_4$	...	Calcium sulphate.
$CuSO_4$	...	Copper sulphate; blue vitriol.
Fe_26CyS	...	Ferric sulphocyanide.
Fe_2Cl_6	...	Ferric chloride; perchloride of iron.
$FeSO_4$	...	Ferrous sulphate; green vitriol.

HCl	Hydrochloric acid; muriatic acid; spirit of salt.
HCy ... ... / HCN	Hydrocyanic acid; Prussic acid.
HNO_3 ...	Nitric acid; aqua fortis.
H_2SO_4 ...	Sulphuric acid; oil of vitriol.
$H_2C_2O_4$ ...	Oxalic acid.
H_2S	Sulphuretted hydrogen.
$HgCl$	Mercurous chloride; subchloride of mercury; calomel.
$HgCl_2$ ...	Mercuric chloride; perchloride of mercury; corrosive sublimate.
K_2CO_3 ...	Potassium carbonate.
K_2CrO_4 ...	Potassium chromate.
$K_2Cr_2O_7$ ...	Potassium bichromate.
K_4FeCy_6 ...	Potassium ferrocyanide; yellow prussiate of potash.
KHO	Potassium hydrate; caustic potash.
KI	Potassium iodide.
$MgSO_4$ ...	Magnesium sulphate; Epsom salts.
MnO_2 ...	Manganese dioxide.
NH_3	Ammonia gas.
NH_4HO ...	Ammonium hydrate; solution of ammonia.
NH_4HS ...	Ammonium sulphydrate.
PH_3	Phosphoretted hydrogen.
$Pb(C_2H_3O_2)_2$	Lead acetate; sugar of lead.
$Pb_2O(C_2H_3O_2)_2$	Lead subacetate; lead oxyacetate.
$PbCrO_4$ ...	Lead chromate; lemon chrome; chrome yellow.
Pb_2OCrO_4 ...	Lead oxychromate; orange chrome.
PbS	Lead sulphide.
Sb	Stibium; antimony.
$SbCl_3$	Chloride of antimony.
$SbOCl$ ...	Oxychloride of antimony; powder of Algaroth.
SbH_3	Antimoniuretted hydrogen.
Sb_2O_3 ...	Oxide of antimony.
Sb_2S_3	Sulphide of antimony.
$SnCl_2$	Stannous chloride; chloride of tin.
SO_2	Sulphur dioxide; sulphurous acid gas.
$ZnSO_4$ ...	Zinc sulphate; white vitriol.

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